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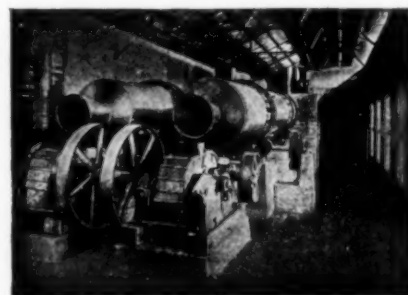
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Number 10

Food Drafts for Relief of Europe

SUPPORTING an appeal from HOOVER is becoming almost a habit with engineers. Beginning with Belgian Kiddies, Ltd., and running through the whole list of plans for the relief of the war-stricken peoples of Europe, members of the engineering profession have gladly lent their support to projects which they knew were worthy. The latest plan devised for the relief of Europe's hunger is the sale of "food drafts" which can be bought at banks in the United States, mailed abroad and exchanged for the equivalent value in food at any one of five central warehouses in Europe. Mr. HOOVER appeals to engineers who are employers of foreign-born labor to bring to the notice of these workmen the easy possibility of assisting their friends and relatives in Europe who may be without sufficient food. As outlined in a letter from Mr. HOOVER, printed elsewhere in this issue, the plan is very simple. Bankers throughout the United States will sell food drafts authorizing the American Relief Administration warehouses at Hamburg, Warsaw, Vienna, Prague or Budapest to deliver to a named individual food to the value of the draft, \$10 or \$50. Hungry Europe needs food and not money; and under the arrangement between the American Bankers Association and the American Relief Administration, it is possible to supply food in addition to that which is available under the rationing system. The plan is highly practicable and we bespeak for it wide publicity and adoption.

Co-ordinating Scientific And Industrial Effort

IF THE war demonstrated one thing more than another to industry in this country, it was the inefficiency of rule-of-thumb methods and the necessity of scientific control. In many cases industrial executives made their first acquaintance with technically-trained men, and while the gap between the educational institutions and the industrial interests of the country cannot be said to have been completely bridged in all instances, it was materially narrowed. Following closely upon our war experience came the Massachusetts Institute of Technology with a plan for co-ordinating its interests with those of our industries in such a way as to promote the welfare of both education and business. Originally evolved as part of Tech's plan to secure endowment funds, the idea is full of promise for the recognition of science and those who apply it. For the next five years the Institute will introduce science to industry through co-operation between its own faculty, students and graduates and those concerns which have contributed to the endowment fund. This will mean five years of accustoming industry to the habit of seeking advice at the hands of scientists and technologists, at the end of

which time a foundation will have been laid for the recognition of chemical and industrial engineers in a greater degree than would otherwise be possible. It should mean five years of the most rapid industrial progress ever made in this country. Details of the Technology Plan, outlined in this issue by Professor WALKER, reveal an idea which can be adapted to other institutions of learning. Indeed we are informed that Cornell already has adopted the plan, and we are assured by the Institute that other colleges and universities are welcome to do so. It was highly successful with its originators, over 190 contracts being made, having a money value in excess of \$1,200,000.

Sewage Disposal And Physical Chemistry

SOME of us who have arrived at years which we hold to be those of discretion, but which are not generally considered to indicate the peak of man's productivity, are likely to grow a little testy about physical chemistry. This is especially the case if we have been lazy in our reading, or if we have let our mathematics and physics drift into those cloudy regions of memory where we keep our Latin grammar and our Greek verbs. We are apt to forget the available fields of research which should precede the methods of trial and error. We wonder if this has not been the case in regard to sewage disposal.

We have considered oxidation in many aspects, chlorination of effluents, the SO_2 reaction and a few other indefinite chemical phenomena, and thereupon we have addressed ourselves to the engineering problems. So we wonder if we have not begun with engineering a little too soon. If there is anything that the conscientious engineer needs to know, no matter of what particular kind he may be, it is the nature of his materials. Now, sewage and its disposal is largely a problem in colloid chemistry, and it may be that the subject has not been adequately studied from the colloid point of view. The chemical behavior of solid substances is largely dependent upon the surface of their particles, and this in turn is determined by the size of them. In such a miscellaneous mess as sewage we have presented a vast field for colloidal study, and the treatment is bound to be chemical if we would change its nature so as to rid it of offensiveness.

It may be that talent and scholarship of the first order in physical chemistry have been addressed to this subject, but if this be true the fact has escaped us. What we should like to see would be a comprehensive study undertaken of the physical chemistry of sewage in a laboratory where modern physicochemical methods of research prevail. It would give the engineers a better show—a better opportunity to design apparatus to meet existing conditions. It may be possible to

coagulate sludge and to separate it from the effluent in a much more effective manner than we now know. With an improved method of separation established it might open the road to a real solution of this perplexing problem. The record of chemistry in regard to sewage is not complete. The case is not closed. Our rivers are still canals of filth, while they carry off to the sea a wealth of nitrogenous material of which we are still in such need that we are at our wits' end to produce it.

An Engineer At the Shrine

These are predestined: if a man love the labour of any trade, apart from any question of success or fame, the gods have called him.

STIMULATED by the vision of a glass maker in his old apron and battered hat, H. L. DIXON recalled the days of twoscore years ago to the enlivenment of the ceramists at their meeting in Philadelphia. One who has thus been associated with an industry from its infancy, who has seen it become a giant in production, is to be envied indeed. All the best in life is not found in things intellectual. There is a call in the heart of every engineer to the handicraft of his business.

Ridiculous Substitute For the Metric System

OPPPOSITION to the proposal to make the metric system compulsory in the United States has produced many foolish arguments, but up to date we have observed nothing quite so inane as the proposal contained in Senate Bill 3,943, the purpose of which is "to establish the standard and decimal divisions of weights and measures and coins of the United States." The bill was introduced "by request" by Senator KING of Utah, who is probably the willing or the unwilling victim of a zealous fanatic.

The bill proposes that after January 1, 1921, the standard for the measure of length and distance shall be the foot, as heretofore. One-tenth of a foot shall be a "decimal inch," one one-hundredth shall be a "line" and one one-thousandth of a foot shall be a "point." One-twelfth of a foot shall also be denominated a "common inch." The multiples of the foot shall be the "double foot, the yard, the quad, the fathom, the decad, the rod, the hundred, the furlong and the mile," whereby, under the grand old Arabic rule of decimal computation, 16½ ft. make one rod and 320 rods make a mile. (Why discriminate against the ancient "cubit," which was standard when NOAH built the Ark?) In measuring plane surfaces a square foot shall be called a "square," and the acre remains, as before, composed of 160 square rods. For volume we are to take a great leap forward by calling a cubic foot a "cube," and the cube of the "decimal inch" shall be called a "decimal cube."

For the measurement of weight we shall have a kind of an ounce which shall be "the weight of the decimal cube of water at maximum density." The decimal divisions of the ounce shall be the dram and the grain, "of which one hundred grains equal one dram and ten drams equal one ounce." Here the zealot's sub-conscious mind evidently referred to fluid measure in the dram, but as our memory serves us one-tenth of an ounce would make a very small pony. A more popular conception of a dram would be a jigger.

Ten ounces are to constitute one decimal pound, and

one hundred decimal pounds one "weight unit," while eight "weight units" equal one "quarter" and ten quarters equal one ton. We shall also have the "common pound" of sixteen ounces. The liquid ounce is to be one decimal cube, and ten liquid ounces will be one decimal pint, while a thousand liquid ounces will be one "liquid cube." For dry measure we are to have "the quart, the pot, the gallon, the peck and the half cube." The mechanical power unit shall be that required to raise one "weight unit" one foot in one second. "The thermal unit shall be the quantity of heat required to raise one ounce of water one degree of the scale of the Fahrenheit thermometer," and we don't know what kind of an ounce it is. For coinage we are to have the dollar, the two-franc piece, the franc and the dime; the nickel, the penny and the cent; and in gold the pound, the eagle and the double eagle.

When we first heard of this bill we presumed it to be a joke, but on receiving a copy from Senator KING we found it to be a fact. We protest against the folly and waste involved in the legislative process of introducing such a bill. The cost of printing and the time of the Senators in session and of the Committee on Weights and Measures to consider and throw out such a fool bill mount into the thousands of dollars, all paid for in taxes by the people of the United States. Besides this we have to consider the far more important interruption of business of world-wide importance, all of which is wasted to meet a fanatic's pleasure. We wonder if there is any possible way of bringing to the consciousness of Congressmen the fact that neither their pleasure nor their political advantage in such matters is worth the price? Compared with this measure the proposal to make the metric system obligatory is the height of sanity; but this sort of a thing, with its different kinds of ounces and inches, its "drams," its "weight units," its "lines," "points," "pots," and so forth, would make confusion worse confounded, as everybody knows. We suggest that if the gifted gentleman who proposed the plan wants to be original, he substitute his ear as the standard of length, thus insuring good measure.

Speaking of Standard Weights and Measures

BROWSING around in ancient literature is usually entertaining, sometimes instructive and occasionally profitable. In an old work on metallurgy and assaying, published in 1799, under the title "Nueva Teórica y Práctica del Beneficio de los Metales de Oro y Plata por Fundición y Amalgamación," JOSEPH GARCES Y EQUIA describes a progenitor of our modern system of assay-ton weights.

Our author and inventor (if, indeed, the idea be original with him) proceeds somewhat as follows:

For fine work, requiring a scorification assay, take one adarme [a Spanish weight equivalent to about one-sixteenth of an ounce troy] and call that a quintal ["assay quintal" being inferred] and divide the adarme into one hundred equal parts, or units, which we will call an [assay] pound. This unit divide again into sixteen parts, which we will call an [assay] ounce. Then by taking an adarme of the sample and using our system of weights we get a figure which corresponds to the pounds and [or] ounces of metal per quintal of ore.

There is also developed a similar system for the calculation of silver expressed in marcos per carga.

Thus we have further proof, if there be need of such, that there is nothing new under the sun.

Political and Commercial Nitrogen

UNBIASED views are particularly valuable at this time in attempting to get a clear-cut view of the situation relative to nitrogen and its compounds. As CHESTER G. GILBERT states elsewhere in this issue, "The discordant grinding of many axes makes a noise from which it is impossible to gather an adequate comprehension" of the facts. The comment is pertinent and is also indicative of the freedom from prejudice with which the author approaches his subject. We commend a careful study of Mr. GILBERT'S views to all who would comprehend the political and commercial activities relative to nitrogen.

The article will also be enlightening to members of Congress and other laymen who have in the past failed to distinguish the terms nitrogen, air nitrates, nitrification, fixation, etc., one from the other. Mr. GILBERT'S discourse is quite within the comprehension of the uninformed.

Nitrogen in tangible and usable form is important to our welfare at all times. The demand for fertilizers is increasing at a rate exceeding the supply, in spite of increased production caused by the war. Consequently, the future policy of the Government and of private industry cannot be decided without serious study, nor can final action be passed on personal or political prejudices. The price of nitrogen in fertilizer has been determined by the cost of the Chilean product, and there is little reason to infer that this condition will be altered for some time to come, even if the Government should operate its own plants.

Steel Corporation Does Not Violate the Sherman Law

IN NEARLY all circles there is an overwhelming feeling of satisfaction that the United States Supreme Court has declared that the United States Steel Corporation is not a violation of the Sherman law. The competitors of the Steel Corporation are well satisfied, its customers are well satisfied and its employees have great grounds for satisfaction. A few doctrinaires and lawyers may be dissatisfied.

It is of interest to note that the law under which the Government instituted its suit October 26, 1911, ten and a half years after the Steel Corporation came into existence, the act approved July 2, 1890, is officially entitled "An act to protect trade and commerce against unlawful restraints and monopolies." The text of the law does not so state, but the circumstances attending its passage have been regarded as indicating that the object was to clarify the existing common law into a definitely worded statute, rather than to prohibit things previously regarded as clearly lawful. To the ordinary observer the evidence has been plain that the corporation's conduct, at least in recent years, has not been such that trade and commerce needed to be protected against it. There are few, undoubtedly, who would deny that the existence of the corporation actually encouraged the growth of independent production.

Nevertheless, the record of the case is that the decision in favor of the Steel Corporation was by a four to three division in the Supreme Court, and that two Justices whom circumstances prevented from participating in the case are commonly assumed to feel unfavorably toward the corporation. It is also to be noted that the majority opinion cites that it would be

injurious to the public interest for the corporation to be dissolved and that the Government omitted to outline a definite method by which dissolution could be effected, giving the dissenting Justices opportunity to assert, in essence, that the law should not be ignored because its execution presents difficulties. It can hardly be said, therefore, that the corporation secures anything at all beyond a mere termination of the suit in its favor, from the legal viewpoint.

Neither the majority nor the dissenting opinion can be found to add anything important to the interpretation of the Sherman law, yet the divergence of the opinions rendered is a definite indication that further clarification of the law is very desirable.

There were many defendants in this suit, all of whom won through the decision, but the really great victory was won by ex-Judge ELBERT H. GARY, chairman of the Steel Corporation since its formation nineteen years ago. Beyond peradventure of doubt it was Judge GARY'S policies that saved the United States Steel Corporation from defeat in the Supreme Court. Judge GARY did vastly more than keep the Steel Corporation from doing things that would have invited an adverse decision in the court. He helped the corporation, directly and in great measure, to succeed in a business way.

The case was really decided upon the conduct of the Steel Corporation. If the decision had been based upon the expectations and intentions of those who brought about the prior consolidations and the formation of the Steel Corporation itself, it requires little reflection to reach a conclusion that the decision would have been different, but the decision plainly writes such expectations out of the case.

This suit of more than eight years' standing being decided, the natural question is, What next? At various times a consolidation of a number of the larger independents has been discussed. It seems fairly clear that no large consolidation could be safe from legal attack. With a four to three decision in favor of the Steel Corporation, which is approximately a 44 per cent interest in point of finished steel-producing capacity, the spectacle of the steel industry's capacity being very largely in the control of two companies would hardly be viewed approvingly.

There is absolutely no reason to assume that the Steel Corporation's price and sales policies will be altered at all by the settlement of the suit. The Steel Corporation's steadfast adherence to March 21 or Industrial Board prices for steel, even beyond the calendar year for which they were formulated, rests upon important business considerations, rather than legal considerations, and undoubtedly has the strong approval of financial interests that are so well represented in the corporation's counsels.

As to investments in plant facilities, on the other hand, there is good reason now for the Steel Corporation to modify its policy. When there was hanging over it the threat of a dissolution, it was imperative that the corporation maintain as large liquid reserves as possible, against the arrangements that would be forced by a decree of dissolution. The occasion for the maintenance of these large liquid reserves has now passed, and the corporation may well address itself, when business conditions warrant, to the investment of a large part of these reserves in property account. In several of its important finished products the corporation now produces somewhat less than 40 per cent of the total produced in this country.

Readers' Views and Comments

Food Drafts for European Relief

To the Editor of Chemical & Metallurgical Engineering

SIR:—I am sure that my fellow engineers will welcome an opportunity to assist in practical support of the relief measure for the civil population of the larger cities in Eastern and Central Europe. We have inaugurated a simple method by which it is possible

(1) For an individual in America to supply a relative or friend in Europe with a food package on payment in dollars at any one of several thousand banks in America.

(2) For anyone desirous of helping to give to the unfortunate without naming a particular relative or friend.

This is made possible by a "food draft" which can be bought at banks, mailed abroad, and is good for the equivalent in food when presented at any one of our five central warehouses in Europe. About four millions of our people are foreign-born or have close foreign affiliations. A large proportion of these people are operatives in our mines and large technical industries.

This is not a "charity" in the ordinary sense of the term, because we give much more than the same number of dollars could possibly buy in Europe if remitted in money at the present rate of exchange. Further, if the transaction is not completed in ninety days, the purchaser of the draft is entitled to a refund, less a small charge for handling. Profits which may be derived from these operations will be credited to the European Children's Fund for child-feeding in the country where the draft is presented.

I earnestly hope you can devote some space to an appeal to the engineers to make these facts known concerning this food draft system and interest the foreign-born in their employ in its possibilities and value. We want their indorsement and their support.

115 Broadway,
New York City.

HERBERT HOOVER.

The Phonograph as an Adjunct to a Research Laboratory

To the Editor of Chemical & Metallurgical Engineering

SIR:—I desire to call attention to the fact that as an aid to scientific research, dictation machines such as the Ediphone or the Dictaphone bid fair to play a prominent part. This is particularly true in so far as the dictation of descriptive data is concerned.

For instance, it is quite feasible for the metallographist to enlist the service of such a help when he has occasion to observe the structure of a specimen under the microscope. His power of description is enhanced, while the field of vision is focused upon the retina. Furthermore, he is in a position to portray vividly the image in its minutest detail.

The prevalent method of recording microscopic data in most research laboratories is to explore the specimen and then write a description of such details as remain fresh in the mind. Much valuable information is lost in this manner; the investigator is later often desirous of writing a more detailed report, but he finds it difficult to depict exactly what he saw.

It is true that microphotographs are a valuable adjunct to scientific research, but their value generally

lies in the phrases that describe them. Moreover, microstructures can be more sharply resolved under the eye piece than on photographic paper, except when the exposure, development and printing are done in the most expert manner.

Briefly stated, the investigator should find it to his advantage to dictate his observations the moment he sees them, and not rely upon memory.

The use of the phonograph may obviously be extended to kindred sciences, such as chemistry, biology, bacteriology and microscopic analysis.

V. E. HILLMAN.
Worcester, Mass.

A Rapid Method for the Analysis of Monel Metal

To the Editor of Chemical & Metallurgical Engineering

SIR:—I have been very much interested in an article appearing in your magazine of Jan. 7, 1920, written by Philip Covitz, entitled, "A Rapid Method for the Analysis of Monel Metal."

To make the method still more rapid, I would suggest the following:

Starting from the filtrate taken from the silicon determination; the filtrate should not consist of more than 125 c.c. Make this solution ammoniacal, which precipitates the iron and aluminum as hydroxides. If much copper is present, a double precipitation is necessary. Dissolve the precipitate in hydrochloric acid, dilute and add about 25 c.c. of a 10 per cent solution of sodium phosphate. Then make ammoniacal, then neutralize with hydrochloric acid, adding not more than 3 c.c. in excess. To this solution add 25 c.c. of a 40 per cent boiling solution of sodium thiosulphate. Boil for at least 10 min. and filter off the precipitate of aluminum phosphate. Wash the precipitate at least five times with boiling hot water and ignite in a porcelain crucible and weigh. Make the filtrate ammoniacal, boil and filter. Dissolve the precipitate of iron, which is in the form of iron hydroxide, in hydrochloric acid, reduce with stannous chloride and continue the determination for iron as given by Mr. Covitz.

I think this method is more simple and will require less amount of time for the determination than the one as outlined by Mr. Covitz because a separate weighing is not necessary for the iron and aluminum determination, as these two elements can be taken from the filtrate of the silicon determination, and because less time is consumed in the method that I have outlined above.

H. A. HORNER.
American Metallurgical Corp.,
Philadelphia, Pa.

Potash From Lakes in Nebraska

To the Editor of Chemical & Metallurgical Engineering

SIR:—Through an unintentional oversight a section of the article on Potassium Salts in vol. 27 of *Mineral Industry* entitled "Potash From Lakes in Nebraska" on pages 584 and following does not give credit in the text to the source from which this material was copied, namely, an article by the same name, written by E. E. Thum and published in *MET. & CHEM. ENG.*, Dec. 15, 1917.

J. W. BECKMAN.
G. A. ROUSH.

Industrial Safety Codes

On Dec. 8 there was held at the Bureau of Standards in Washington a notable conference on industrial safety codes, at which there were representatives of practically all organizations of a national scope interested in any of these wide phases of industrial safety. The conference grew out of an earlier one held on Jan. 15, 1919.

There was a thorough discussion of the whole situation, the consensus of opinion being that there should be a large number of industrial safety codes—perhaps fifty or even one hundred—developed during the next few years.

The conference unanimously voted that the preparation of all such safety codes should be under the auspices and rules of procedure of the American Engineering Standards Committee.* In accordance with the recommendation of the conference, the American Engineering Standards Committee requested the International Association of Industrial Accidents Board and Commissions, the Bureau of Standards, and the National Safety Council to organize a Joint Committee on Safety Codes, this committee to include representatives of these bodies, and such others as they may consider advisable.

In compliance with this request the three bodies have organized such committee, the personnel of which is:

D. S. Beyer, Boston, Mass.; Edward F. Boyle, Albany, N. Y.; C. B. Connelley, Harrisburg, Pa.; L. A. de Blois, Wilmington, Del.; W. C. L. Eglin, Philadelphia; George P. Hambrecht, Madison, Wis., represented by R. McA. Keown, Madison, Wis.; M. G. Lloyd, Washington, D. C.; Royal Meeker, Washington, D. C.; Dana Pierce, New York, N. Y.; C. C. Rausch, New York, N. Y.; Calvin W. Rice, New York, N. Y.; John Roach, Trenton, N. J.; E. B. Rosa, Washington, D. C.; A. W. Whitney, New York, N. Y., and S. J. Williams, Chicago, Ill.

It is planned to add two more members to the committee, one each from the Ohio and the California commissions.

The committee held its first meeting in Washington on Jan. 9, at which time tentative recommendations were formulated for about thirty safety codes. This committee, which represents in its own personnel a large range of interests, is actively at work. It is consulting a large number of other interests involved. Rapid progress is being made and it is expected that the committee will soon render an important preliminary report.

Regulation Affecting Transportation of Denatured Alcohol in Texas

Under the Dean law in Texas, no carrier can deliver denatured alcohol to the consignee without the permit required by this law. The United States Railroad Administration failed to take out such a permit for 1920. The attention of the Texas Chamber of Commerce was called to this situation by the First Texas Chemical Co., of Dallas, its plant having been forced to shut down for lack of denatured alcohol.

Upon telegraphic representations made by the Chamber of Commerce that failure to take out this permit promptly had prevented carriers from delivering denatured alcohol, thereby handicapping the chemical industry in Texas, the regional director ordered that a permit under the Dean law be taken out for Texas railroads then under Government control.

*See CHEM & MET. ENG., Feb. 18, 1920, p. 294.

Civil Service Examinations

The following examinations are announced by the Civil Service Commission:

Petroleum engineer, \$3,000 to \$4,500 a year; assistant petroleum engineer, \$2,100 to \$3,000 a year. Vacancies in Bureau of Mines for duty in Washington, D. C., or in the field will be filled from these examinations. Apply on Form 2,118 before March 16.

Geologic aid and assistant geologist for duty with United States Geological Survey at salaries ranging from \$100 a month when actually employed to \$1,800 a year. Apply at once for Form 1,312. Examination will be held March 17 and 18.

Automatic scale expert for duty in the Customs Service, New Orleans, La., at \$1,600 a year. Applicant must be familiar with construction, operation and care of automatic and electric scales. Form 1,312 is to be used in applying for examination, which will be held March 17.

Foreman, heat treatment for armor plate, \$10 to \$14.40 a day; foreman, heat treatment of large guns, \$8 to \$12.56 a day. Vacancies at U. S. Naval Ordnance Plant, South Charleston, W. Va. Apply on Form 1,371 before March 23.

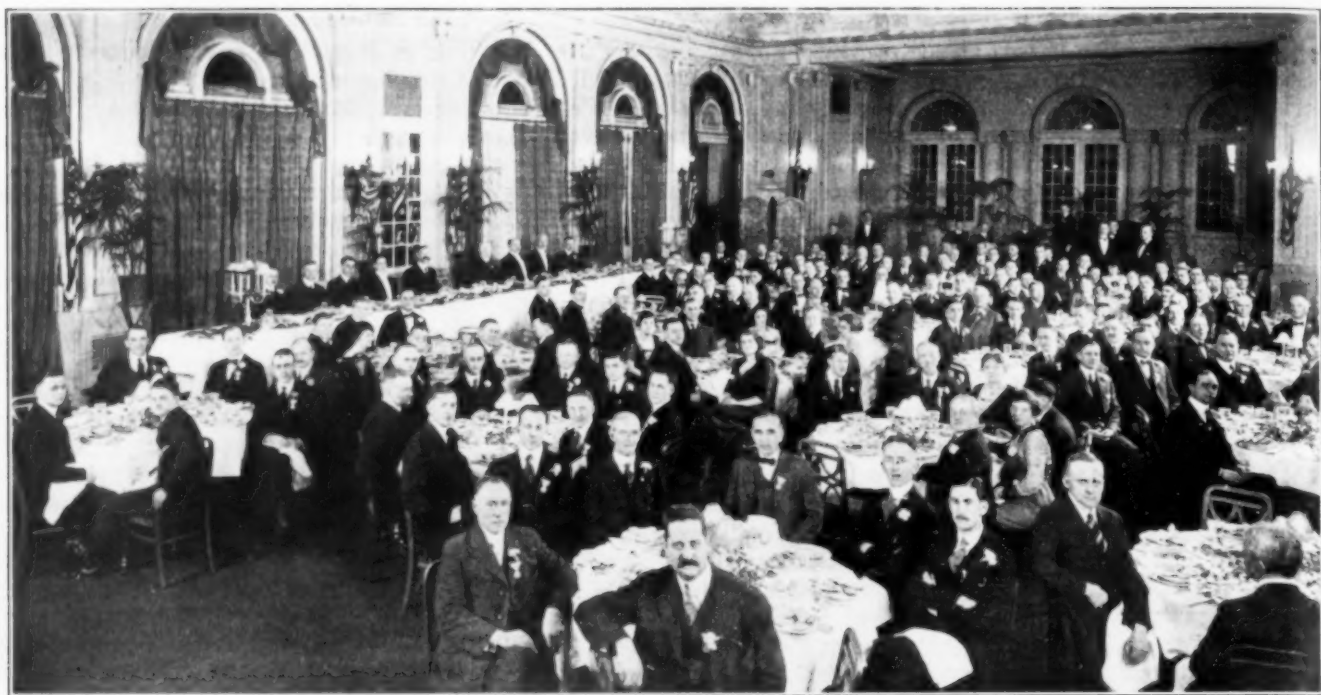
Valuation aid, \$1,200 to \$2,500 a year; assistant valuation engineer, \$2,500 to \$3,600 a year; valuation engineer, \$3,600 to \$4,800 a year. Vacancies in technical staff of Income-Tax Unit of Bureau of Internal Revenue, Treasury Department. The duties of these positions will involve estimation of: (1) The quantity of mineral or oil and gas or timber; (2) theoretical and market values of mineral or oil and gas in place or standing timber, and their products; (3) value of equipment used in developing these natural resources; (4) cost of development, exploitation and utilization of these natural resources. Applications will be received on Form 1,312 until further notice.

Meeting of California Section, A. C. S.

The monthly meeting of the California Section of the American Chemical Society was held in the rooms of the Engineers' Club of San Francisco Thursday evening, Feb. 26. Two papers were presented. The first, by Dr. W. C. Bray of the University of California, on "The Practical Application of Catalysis," dealt with the successful development of catalysis for use in gas masks to bring about the oxidization of small amounts of carbon monoxide. The second paper was by Dr. E. D. Eastman, of the University of California, on the subject of "The Reduction of Iron Oxides by Fuel Gases." Dr. Eastman discussed the theoretical aspects of the subject, which was studied with the object of determining the practicability of the production of iron from the calcines resulting from roasting sulphide copper ores containing pyrites, the iron produced by this process to be used for the precipitation of copper from sulphate solutions.

Land Leasing Bill

Friends of the oil land leasing bill were kept on the anxious seat until the eleventh hour by the President, who signed the bill on the afternoon of the day on which the bill would become a law automatically. It had been rumored that the President intended to veto the measure. In addition to oil, the act provides for the leasing of coal, phosphate, gas, and oil shale.



BANQUET OF AMERICAN CERAMIC SOCIETY, PHILADELPHIA

The Philadelphia Meeting of the American Ceramic Society

Report of the Twenty-second Annual Meeting—Addresses of the General Session—Selection of the Papers Read Before the Enamels, Glass, Refractories, Terra Cotta and Porcelain Divisions

THE twenty-second annual meeting of the American Ceramic Society opened at the Bellevue-Stratford Hotel in Philadelphia Feb. 23, 1920, with an address by President R. T. Stull, who outlined the need of technical research in the clay industries. There is now manufactured in the United States about \$500,000,000 in ceramic products per annum, one-half of which are clay, the remainder enamels, etc. Every state is engaged in the industry. Brick is the largest in tonnage and value.

Seventy per cent of the cost of production is labor and fuel. There is great room for reduction of these costs through the adaptation of mechanical devices and automatic machinery. The price of brick has trebled in the last ten years.

The tunnel kiln will play a large part in fuel economies. The time will come when brick will be produced automatically throughout the process; but no company has the capital to undertake this development at present. Secretiveness and patent conflicts choke the progress. Either a brave corporation must enter the development or a central corporation must be organized with large research laboratory and mechanical plant.

Business Meeting

Reports of the committees showed the business affairs of the society to be in good condition. The total membership is 1,228 with an average increase of twenty-five

new members per month. The committee on ceramic research, co-operating with the National Research Council, has proposed establishment of fellowships as a means of solving the fundamental problems. It is necessary to know not only the how but the why. Every works problem is a fundamental one.

These fellowships should be established by the manufacturing companies and there are two classes, as follows:

Class A: The stipend for this class of fellowships shall be \$800 for the first year and \$1,000 for the second and each subsequent year. A holder of this class of fellowships shall carry out his research work at a university and shall have the privilege of becoming a candidate for an advanced degree at that university, and of taking such advanced courses as may be necessary thereto.

Class B: The stipend for this class of fellowships shall be \$1,600 for the first year, \$1,800 for the second year and \$2,000 or more for subsequent years. The holder of one of this class of fellowships shall be a trained research worker and shall devote all of his time to the research work.

The special committee on definition of the word "ceramics" delivered a long report giving the complete etymology of the term and concluding with the statement that there is no barbarism when the word is applied to the present field of the American Ceramic

Society. Ceramic industries are those which manufacture products by the application of heat to earthy materials, and ceramic engineering is that branch of engineering which deals with the ceramic industries.

ELECTION OF OFFICERS

The election of the following officers was announced for 1920: R. H. Minton, president; E. T. Montgomery, vice-president; R. K. Hirsch, treasurer; Charles F. Binns, secretary; F. H. Riddle, member of board of trustees; Homer F. Staley, editor of the *Journal*.

Papers Presented

A total of 139 papers read and a symposium on tunnel kilns compared favorably with the fifty-eight offerings of last year. Monday was devoted to the

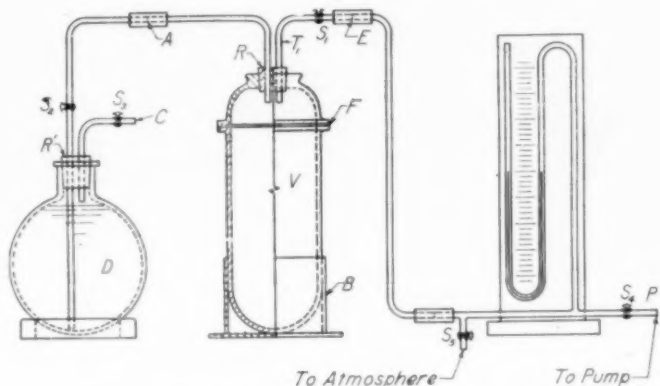


FIG. 1. APPARATUS FOR TESTING POROSITY

presentation of general papers, while the following days were occupied in divisional meetings.

CLASSIFICATION OF CLAYS

A. S. Watts proposed a classification of clays on a ceramic basis. At present there is much confusion as to the definition of kaolin. This is true of ball clay, and the specification regarding fire clay is even more vague. Fire clay is now understood to refer to "coal-measure clay." It should be based on refractoriness, say above cone 27. General classification should be made according to ceramic properties as evidenced by color, shrinkage, bonding strength, vitrification and fusion.

TESTING OF CLAY FOR LIGHT-WEIGHT CONCRETE AGGREGATE

D. H. Fuller, of the Bureau of Standards, spoke on testing of clay for light-weight concrete aggregate. Tests have been made on clays intended to produce, when fired, a light vesicular mass, suitable for concrete work. Such clays must be hard but not overfired, containing a large volume of pore space so that fresh specimens will float in water. The density of clay structure, the amount and character of carbon and the presence of sulphates and sulphides seem to affect the requirements. Materials which fail to float in salt solution of specific gravity 1.1 or which contain large cavities are unsuitable.

DETERMINING POROSITY OF CLAYS

Edward W. Washburn and Frank Footit gave the results of experiments on the source of error in the methods of determining porosity of clays using the apparatus shown in Fig. 1.

(1) Place the cold test piece in a desiccator over 95

deg. sulphuric acid and allow it to remain till it reaches constant weight. This process may be hastened, if desired, by evacuating the desiccator.

(2) Place the weighed test piece in a vacuum vessel and evacuate the air until the manometer reads less than $P = \frac{AB}{100}$. Here B is the barometric reading and

A is the percentage accuracy desired in the result. Then admit to the vacuum vessel enough air-free cold (the colder the better) distilled water to cover the test piece. Break the vacuum immediately, bring the water to room temperature, remove the test piece, wipe with a very damp towel and weigh. If the pump is not good enough to give the degree of vacuum indicated by the above equation, the vacuum vessel should be warmed until the water will boil under the vacuum obtained, and this boiling should be continued for about one hour.

A series of comparative experiments with water and paraffine, using the same test pieces, was carried out and the results were found to check within close range. Fig. 2 shows gain in weight with porosity test. A perfectly burned piece of dry clay is a better drying agent than calcium chloride or sulphuric acid.

STORING AND HANDLING RAW CLAYS

T. W. Garve, in outlining a plant for the storing and handling of raw clays, emphasized the need of mechanical equipment in all such operations. Shales should be crushed before storing. Flat conveyors wear longest

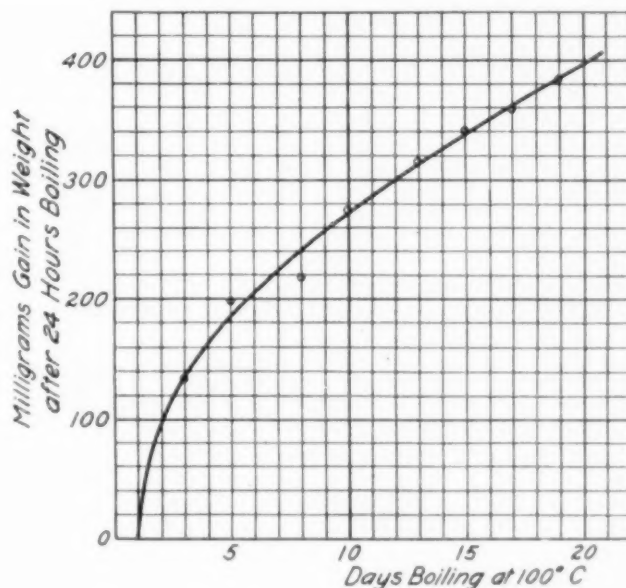


FIG. 2. GAIN IN WEIGHT—POROSITY TEST

and belt speed should be about 125 ft. per min. Details of machinery layout and buildings must conform to good mechanical and architectural practice.

COBALT OXIDE

N. B. Davis read a paper on cobalt oxide. Its use as a coloring matter in ceramics dates back to the early Chinese. The world supply for many years came from the cobalt-silver deposits of Saxony, and later from Missouri and Canada. Annual consumption in the United States amounts to 240,000 lb., most of which was used for ceramic ware. This is now being shared with the steel industry and chemical processes for drying the soya bean.

Other papers given were:

"Theory and Practice of Fractional Calcination of the Dolomites," by G. A. Bole and George Blumenthal.

"Experiments in Dead Burning Dolomite and Magnesite," H. G. Schurecht.

"Combustible Matter in the Chicago Clay," A. Malinovsky.

"A Direct Reading Overflow Volumeter," H. G. Schurecht.

"The Grain Sizes of Clays and the Relationship of the Grain Sizes of Certain Clays to Plasticity and Service," R. Thiessen and R. B. Gilmore.

"Fused Artificial Sillimanite," A. Malinovsky.

"Effect of Oxidation and Reduction on the Fusibility of Iron Oxide-Silica Mixtures," W. H. Reid.

"Further Study of $MgO-Al_2O_3-SiO_2$ Mixture," A. S. Watts.

"Methods of Testing Sagger Mixtures," S. C. Linbarger and C. F. Geiger.

"Waste Heat Drier Construction," E. Roddewig.

"Experiments With Aventurine Glazes," H. G. Schurecht.

"Some Luster Pottery Decorations," R. T. Watkins.

"Cost of Materials vs. Final Cost of Fired Pottery and Glass," George F. Hasslacher.

"Drying," William W. Wilkins.

Enamels Division

Papers in this division were accompanied by interesting discussions which evidenced the fact that the development has been slow owing to research being carried on by independent investigators. Considerable difference of opinion exists on important phases. The new subjects taken up were:

"Electric Cleaning of Metals for Enameling Purposes," W. C. Lindemann.

"Fish-scaling," J. B. Shaw.

"Fish-scaling of Gray Ware Enamels," R. R. Danielson.

"Cause of Fish-scaling in Enamels," R. C. Charron.

"Relative Action of Acids on Enamel—IV," E. P. Poste.

"Notes on Mottling of Enamels," R. C. Charron.

"Some Relation of Composition to Solubility of Enamels in Acid," H. F. Staley.

"Acid-Proof of Cast-Iron Enamel," H. F. Staley.

The last paper, covering a series of tests which are still under way, showed that the best oxides for acid-proof enamel as tested in a 20 per cent solution of HCl are SiO_2 , BaO , PbO and Al_2O_3 . The poorest results were obtained with ZnO , CaO , MgO , B_2O_3 and Na_2O .

Glass Division

H. L. Dixon, an old-time glass maker of forty-three years' service in the industry, delivered an inspiring address before this division under the subject, "Ancient and Modern Methods of Glass Manufacture." He told how the business, starting in Pennsylvania in 1843, migrated through Ohio, Indiana and Kansas following the development of natural gas properties. There have been losses extending over many years because there were no chemists on the job. Expensive materials were imported and glass makers produced their own refractories. Every factory should have a chemist. Science means so much to the business. A chemical education is necessary to the glass manufacturer's success at the present time. But the graduate must not make the

mistake of analyzing everyone he meets by chemical equation. He should put on the undershirt, overalls and old hat and, going into the factory, win the confidence of the practical man, exchanging ideas with him. Colleges should teach the equality of the two types.

The word "can't" has been stricken from the vocabulary of the glass industry. Large things are ahead. The electric furnace in glass melting is the next step.

Other unpublished papers were given and discussed as follows:

"Glass Sand Resources of Pennsylvania," Charles R. Fettke.

"The Present Glass Situation," S. W. Stratton.

"Producer Gas as Fuel for the Glass Industry."

"The Art of Pot Making," Charles O. Grafton.

"Study of Some Glass Pot Clays," D. H. Fuller.

"Note on Porcelain Glass Pot Mixtures," D. H. Fuller.

"The Relation Between Refractivity and Chemical Composition in Optical Glasses," F. E. Wright.

"A Practical Test for the Resistance of Optical Glass to Weathering," F. R. Bichowsky.

"A Method of Determining Thermal Expansion of Glass," C. C. Rand.

"Note on the Mechanics of the Weathering of Glass," F. R. Bichowsky.

"The Annealing of Glass," L. H. Adams and E. D. Williamson.

"The Composition of Lead Glasses," R. J. Montgomery.

MEASURING VISCOSITY OF POT-MADE GLASS

E. W. Washburn submitted a factory method for measuring the viscosity of pot-made glass during the process of manufacture. This includes the introduction of thermocouple into stirrer as shown in Fig. 3.

Refractories Division

D. W. Ross offered notes on silica brick. Not many careful studies have been made on the combined effects of thermal expansion as it occurs in the crowns of industrial furnaces. Study made on a bottle-glass

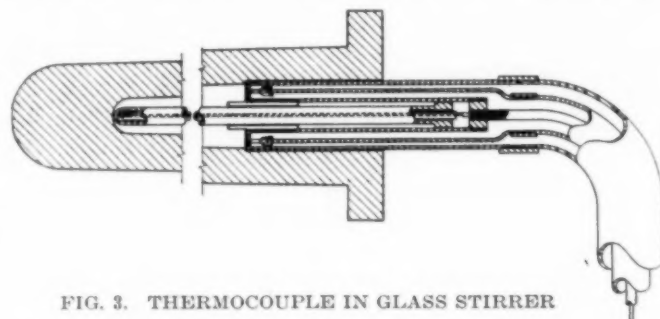


FIG. 3. THERMOCOUPLE IN GLASS STIRRER

furnace over a period of years led to the conclusions that (1) great care is necessary in heating up a new crown; (2) after eighteen months a crown can be slowly cooled without disruption; (3) a reheating of the cooled furnace gives less trouble, as the expansion is about one-half as great as during the initial heat; and (4) when crown is cooled after eighteen months' service the zone of weakness is found midway between the inside and outside of the crown.

DESIGN OF A FIREBRICK PLANT

R. H. Minton's paper on the design of a firebrick plant was of especial interest to the manufacturers of refractories. In designing the process it should be

made as automatic as possible, compactly arranged and involve efficient burning. Complete layout was given, showing three wet pans, three rotary driers and three dry pans.

SILLIMANITE DEVELOPMENT

A. S. Watts offered a possible explanation of failure under load at high temperatures as displayed by fireclay refractories. A peculiar combination of facts discovered over a period of years points to sillimanite development in the following points:

(1) Sillimanite is known to develop at about the temperature of observed failure.

(2) The sillimanite development through molecular rearrangement and not by crystallization out of solution would occur during the heating up process and does not require any definite period of exposure to the elevated temperature.

(3) The hard burning of the refractory prior to test could cause the sillimanite rearrangement in the mass and thus reduce the amount of strain due to sillimanite development at the time of test. This explanation of the improvement due to hard burning is at least as logical as that the advanced solution of the flint clay gave it strength under high temperatures.

(4) The increase of SiO_2 as a means of improving strength at elevated temperature can be explained as also reducing the Al_2O_3 content to a point at which the development of sillimanite is very small or nil, and thus its weakening influence is not displayed.

(5) The low sillimanite development in ball clays may explain their freedom from weakness at temperatures where fireclays and pure kaolins fail, and as they have no associated material of greater refractoriness which they can absorb, the explanation of their superior behavior must lie within themselves.

Other papers under this division were as follows:

"Mica Schists as Refractories," J. S. Hibbs.

"Conductivity of Refractories and Methods of Testing Conductivity," by S. F. Walton and F. H. Riddle.

"Magnesite Refractories," J. S. McDowell and R. M. Howe.

"Tests on a California Refractory Clay," H. W. Douda.

"Testing Refractories," F. A. Harvey.

"Refractory Clays of Missouri," I. A. Krusen.

"Behavior of Firebrick in Malleable Furnace Bungs," H. G. Schurecht.

"Note on the Load Behavior of Aluminous Refractories," A. V. Bleininger.

"An Industrial Laboratory for Research in Ceramics With Note on the Construction of a Novel Testing Furnace," S. F. Walton.

"Siliceous Sagger Mixtures," M. R. Hornung.

"Behavior of Bond Clays in Graphitic Crucibles Under Brass and Steel Melting Practices," R. T. Stull.

"Use of the Microscope in Crucible Making," R. Thiessen and R. B. Gilmore.

"The Fusibility of Mixtures of Graphite Ash and Bond Clays," R. N. Long.

"A Rapid and Approximate Method for Determining the Melting Point of a System Composed of Highly Refractory Materials," E. W. Washburn.

Terra Cotta Division

R. L. Clare and D. F. Albery have investigated the effect of variation in the size of the grog in terra cotta bodies, and results showed clearly that if the terra cotta is to be kept uniform in its physical properties the grog size must be controlled. To accomplish this the grog must be specially prepared and ground under stated conditions. It must be selected and burned under specifications. A central plant operating for several companies was suggested. The extra cost would be more than offset by advantages resulting.

R. H. Minton in searching for a substitute for tin oxide found that little work has been done outside the enameled ware field. Results showed that tin oxide is the best opacifier, although "terror" and zirconium oxide offer possibilities. Zinc oxide is of great assistance in producing capacity when used with tin oxide. Barium also exerts a marked influence, while a combination of barium and zinc has more effect than the clay content, giving more favorable opacity. Antimony oxide and "leukonin" are cheaper than tin where applicable. Zirconium has proved to be the best substitute, but it is too expensive.



R. H. MINTON
President, 1920, American Ceramic Society

RESEARCH ON VERMILION COLORS

Charles F. Binns and Frobisher Lytle in research on vermilion colors made two glazes, one with 20 per cent commercial yellow oxide of uranium content and the other using 37 per cent. The first

gave a bright vermilion color. Some difficulty has been experienced in protecting uranium oxide from reducing influences in firing, but with complete oxidation these colors seem to be commercially possible.

J. D. Whitmer presented the results of a glaze study involving some interesting colors produced by nickel oxide which demonstrated that grays are obtained from nickel oxide in the presence of magnesium oxide.

Other papers presented and discussed were:

"The Effect of the Size of Grog Particle in a Terra Cotta Body," H. E. Davis.

"Discussion of Humidity Drying of Terra Cotta," B. S. Radcliffe.

"Satisfactory Method of Using Barium Hydrate in Place of Barium Carbonate to Take Care of Soluble Salts in Terra Cotta Bodies," M. E. Gates.

"Some Data on the Composition of Kiln Gases and Their Effect on Terra Cotta Glaze and Colors," F. B. Ortman.

"Discussion of Spalling of Enamel Terra Cotta After Erection in Building," F. B. Ortman.

"The Effect of Glaze Composition on the Crazing of Terra Cotta," E. C. Hill.

White Ware, Porcelain, Etc.

A. S. Watts presented the draft of a complete set of specifications for flint and another for feldspar under the following headings:

1. Sampling.
2. Chemical composition.
3. Physical properties and tests.
 - (a) Color.
 - (b) Fineness of grain.
 - (c) Moisture content.
 - (d) Fusion behavior.
4. Rejection.

SUBSTITUTE FOR GERMAN CLAYS

Jerome Alexander outlined preliminary ultramicroscopic examinations of clays during the war in determining the proper American substitutes for German clays, which showed that a thorough study of clays along the lines of colloid-chemical principles and analysis will throw much light upon many obscure phenomena met with by clay users. These factors extend their influence not only to the formative part of the ceramic processes, but to the subsequent drying, baking and firing, and the effects are traceable to the zone of actual fusion.

TESTS ON RATE OF VITRIFICATION

R. F. Sherwood gave the results of tests on the rate of vitrification of porcelain molded under different conditions. The initial structure of a clay body governs the rate of contraction and vitrification. A comparison was made to show the difference in the rate of vitrification of one and the same body molded by hand pressing in the plastic state, by casting and by dry pressing at different pressures and finally firing simultaneously in the same kiln, giving identical heat treatment. The cast gave the most dense body and the plastically molded body had the most rapid rate of vitrification.

Other offerings were as follows:

"The Use of Domestic Kaolins in the Manufacture of White Ware Pottery," A. V. Bleininger and W. W. McDanel.

"A Possible Explanation of the Differences in the Behavior of Potter's Flint and Ground Quartz in Pottery Bodies and Glazes," E. W. Washburn.

"Tests of Commercial Samples of Feldspar and Flint," B. E. Sockman.

"The Effect of Wet Grinding, Screening, and Electrolytes on Clays of Low Plasticity," H. W. Doula.

"Elutriation Tests on American Kaolins," H. G. Schurecht.

"The Effect of Aluminum Chloride Upon the Plasticity of Kaolins," H. P. Reinecker and J. S. George.

"The Effect of the Method of Preparation on the Viscosity of a Casting Slip," V. S. Schory.

"Some Problems in the Manufacture of Sanitary Porcelain," Samuel Bedson.

"Structure of Porcelains," H. Spurrier.

"Note on Zirconia Porcelain," A. V. Bleininger.

"The Solubility of Some White Ware Glaze Frits," George Blumenthal, Jr.

Kilns

The symposium on tunnel kilns developed little criticism of the tunnel kiln by the users of periodic kilns, but rather resulted in an argument between tunnel kiln manufacturers as to the relative merits of the direct-

fired and the muffle-fired types. The chief advantages of the latter are the economy of fuel effected, better control in firing, convenient handling of materials, elimination of saggers, and smaller maintenance cost due to continuous heat. On the other hand, there is a question of less capacity and more floor space. The coming year should develop some real data for comparative figures.

Entertainment Features

The smoker held on Monday evening proved a marked success due to the feature event, a farce presented by the New York Student Section, entitled, "A Day in the Secretary's Office." The adaption of new lines to well known tunes was welcomed enthusiastically by the audience. The Ceramic Engineers' Song was especially applauded as to the last verse, which runs:

Oh, we're Ceramic Engineers,
We're not so very neat,
We never change our underwear,
We never wash our feet,
We wear our collars and cuffs for months,
With grime and dirt they're smeared,
Oh, we're the very scum of the earth,
Ceramic Engineers.

The banquet under the skillful direction of Francis Walker, Sr., was most pleasurable. Mr. Cattell, the Philadelphia statistician, was there with his usual greetings to which everyone looks forward at these conventions. He said "au revoir" meant "goodby" in France, but "carbolic acid" meant "goodby" in every country. He finished with a truly Cattell appeal for "Americanism." The applause continued with everyone standing for many minutes. Calvin O. Althaus delivered an eloquent address.

The whole affair was just informal enough to carry the right appeal.

The Philadelphia Section

The work of the local section in providing everything necessary for convenience and comfort of the visitors received a unanimous vote of thanks at the business meeting. Trips were made to places of interest and industrial plants on Thursday.

Electrochemists and Electrical Engineers to Meet Jointly in Boston

Plans for the joint session of the American Electrochemical Society and the American Institute of Electrical Engineers at Boston, April 8, 9 and 10, are progressing so favorably that there is every promise of an unusually good meeting. The symposium on electrically-produced alloys will be opened by H. E. Howe, with a paper on "Fundamental Problems in Alloys Research." The manufacture of ferro-alloys in general will be discussed in two papers by R. J. Anderson and C. B. Gibson. Other special alloys on which papers have been prepared are ferrovanadium by B. D. Saklatwalla; ferrosilicon by F. A. Raven; nickelchrome by W. B. Driver, Jr.; cobaltchrome by Ellwood Haynes; ferromanganese by E. S. Bardwell and high-speed steel in the electric furnace by R. C. McKenna.

The session on power requirements for electrochemical industries will be addressed by H. A. Winne, C. A. Winder and John A. Seede. Other papers of technical importance are "Nitrogen Fixation by the Silent Electric Discharge," by C. F. Harding, and "Magnetic Properties of Iron-Nickel Alloys," by T. D. Yensen. There will also be a symposium on colloids.

Political and Commercial Control of the Nitrogen Resources of the World—I

A General Review of the Sources of Nitrogen: Atmospheric, Nitrate Ore, Organic and in Carboniferous Deposits, With a Description of the General Aspects of the Control of Nitrogen Resources in Normal and War Times

BY CHESTER G. GILBERT*

PLANT life requires nitrogen, and gets it in the normal cycle of events. But when the occasion calls for stimulating the growth of plant life by feeding—by soil fertilization, in other words—nitrogen in available form is indispensable. Further down along the channels of food supply it exercises another and equally important function in providing the chemical around which the modern practice of refrigeration is built. Likewise, the chemistry of explosives is basically the chemistry of nitrogen compounds. Nor is this all, for chemical operations in general, hence research and industrial chemistry in general, involve the employment of nitrogen compounds. Such, in brief, is its social status. On each of three major counts—the interests of food production, of food distribution, and of national defense—it is indispensable; and of no less consequence is the retinue of less conspicuous agencies serving the interest of chemistry at every turn.

The development of fixed nitrogen sources is conditioned by three simple chemical facts. With these three simple facts in mind the rest follows largely as a matter of inference. They are:

1. That under all ordinary conditions of temperature and pressure, free nitrogen is a gas.
2. That it is extremely inert and indisposed to participate with other elements in the formation of chemical compounds.
3. That such combinations, when they do occur, are characteristically soluble.

In consequence of these three governing principles, along with its relationship to organic matter as alluded to above, nitrogen has four habits of occurrence worth considering as at least potential sources of supply; namely, atmospheric nitrogen, nitrate ore deposits, organic nitrogen and nitrogen in carboniferous deposits.

Atmospheric Nitrogen

Being indisposed to participate in chemical combinations, nitrogen in the course of world evolution was left largely to itself; and since in the free state it is normally gaseous, it established its home in the atmosphere. Thus it comes about that the atmosphere today is approximately four-fifths nitrogen gas, and after all is said and done the atmosphere is bound to constitute the great source to which we must turn for our supplies. With a source so boundlessly ever-present, the question of supply at first glance looks simple enough. But atmospheric nitrogen, it must be remembered, is nitrogen uncombined, and the demand is not for nitrogen itself but for nitrogen-bearing compounds. Once in a state of combination, it may remain so indefinitely, and

the form of combination may be changed more or less readily to suit the demand. Before it can be put to use, however, it must be induced to surrender its gaseous freedom and affix itself in some such state of combination. The free nitrogen must become fixed nitrogen—hence the terms fixed nitrogen, nitrogen fixation and the like in common use. Toward this end it must be induced to do what it has not seen fit to do of its own accord, and the very trait of aloofness responsible for the inexhaustible resources of atmospheric nitrogen stands as an obstacle opposing their utilization. The obstacle has not proved insuperable, as will appear later; but it is sufficiently a source of trouble even to this day, so that the fixed-nitrogen situation may with peculiar appropriateness be characterized as distinctly in the air.

Nitrate Ore Deposits

The disposition on the part of nitrogen to take up its abode in the atmosphere has an obvious result in minimizing the development of mineral nitrates. Atmospheric nitrogen is not entirely stagnant, however. Natural processes are constantly at work effecting substantial fixation. The processes are not obtrusively energetic, as in the case of atmospheric oxygen, whose fixation processes constitute the ever-present phenomena of oxidation. Still in various ways, the most prominent among which is undoubtedly a form of bacterial action, nitrification and the building up of nitrate minerals everywhere in the soil goes quietly forward, and their concentration in ore deposits of more or less plentiful occurrence is thus to be looked for in the natural course of geologic events.

DEVELOPMENT OF NITRATE ORE DEPOSITS

In attempting to trace their further course, however, we are confronted at the outset by the principle of solubility. The nitrate minerals are in the nature of soluble salts. They leach from the immediate environment in which they form, just as do the soluble minerals in general. Mostly these latter are carried in solution to the ocean, adding themselves to its salinity; but under exceptional conditions of topography where the drainage feeds into land-locked basins, the water finds itself entrapped with no avenue of escape except through evaporation. Here the salts accumulate, become concentrated, and finally give rise to deposits. This, in outline, is the course set for the soluble mineral salts as a class, and it is along this course that we must expect to trace the development of nitrate ore deposits.

DISSOCIATION OF NITROGEN COMPOUNDS

But the ocean with its 3½ per cent of salinity has only traces of nitrate minerals; and the same is true for the waters of land-locked basins, in all the various stages of concentration. Their solubility is such that they cannot

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*Curator of Mineral Technology, U. S. National Museum.

TABLE I. STATISTICS OF NITROGEN PRODUCTION

Year	Organic Nitrogen Dried Blood, Tankage, Guano, Fish Scrap, Cottonseed Cake and Meal, etc.	Chemical Nitrogen										
		Sodium Nitrate			Fixation Compounds						Byproduct Ammonium Sulphate	
		World's Production, Tons	Domestic Production, Tons	Imports, Tons	World's Production			Domestic Production, Tons	Imports, Tons	World's Production, Tons	Domestic Production, Tons	Imports, Tons
					Ammon. Sulph. (Haber) Tons	Calcium Nitrate (Arc), Tons	Cyana- mide, Tons					
1900										540,000	27,600	8,411
1901		1,328,664		203,960						580,000	29,279	14,486
1902		1,349,300		205,245						600,000	36,124	18,146
1903		1,485,279		272,947						640,000	41,873	16,777
1904		1,559,091		228,012						650,000	54,664	16,667
1905		1,754,605		321,231						694,575	65,296	15,288
1906		1,800,500		372,222			386			778,365	75,000	9,182
1907		1,846,036		364,610			1,874			906,255	99,300	30,114
1908		1,970,974		310,713			2,767			970,700	83,400	38,238
1909		2,110,961		428,429		45,450	12,734			987,840	106,500	42,914
1910		2,465,415		529,172			22,596		764	1,104,705	116,000	92,342
1911		2,521,023		544,878			59,479		5,617	1,206,135	127,000	94,633
1912		2,585,850		486,352			115,688		7,134	1,356,075	165,000	59,542
1913		2,772,254		625,862	20,000	181,800	173,026		14,656	1,532,475	195,000	65,775
1914		2,463,356		541,715	60,000		208,070		29,536	1,320,000	183,000	75,010
1915		1,755,291		772,190	150,000		845,388		20,564	1,690,000	249,000	36,370
1916		2,912,893		1,218,423	300,000		1,053,439		38,023	2,000,000	285,000	12,962
1917		2,950,000		1,555,839	500,000	300,000	954,765		44,146		325,000	
1918		2,900,000		1,845,192					43,070			

have escaped in substantial form along the way. There is only one inference to be drawn. Evidently the inherent trait of aloofness is not lost to nitrogen when it does combine. The compounds do not survive for any length of time, but suffer dissociation, releasing their nitrogen and returning it to the atmosphere even as other processes are slowly withdrawing it therefrom.

With this the eternal cycle is closed for nitrogen, and closed without apparent provision for any considerable sidetracking such as would be required in the building up of ore deposits.

So much for the rule; now as to the exceptions. Mostly they are of minor consequence. Pockety enrichments in the soil are common. Accumulations tend to build up in caves and may even grow to be of consequence in a small way, as during the Civil War when they helped materially toward relieving the nitrogen troubles of the blockaded Confederacy. In arid country, too, they not infrequently assume sufficient prominence to be of interest especially at the hands of the promoter. Finally, there are the Chilean nitrate fields, which far from being of minor consequence, go to the other extreme in catering to the needs of the entire world. These occurrences, especially the last named, have served to keep alive the hope that others of economic importance await discovery. The Chilean deposits alone among them all deserve more than passing notice.

ORIGIN OF THE CHILEAN NITRATE DEPOSITS

The origin of these deposits is veiled in uncertainty. Just why or how the natural forces, which elsewhere as a matter of universal observation have been seen to oppose both the formation of nitrogen salts and the accumulation of such as do manage to form, should have failed in this particular instance remains wholly conjectural. A conclusive explanation would be of the utmost value in determining the likelihood of similar occurrences elsewhere. But none has been forthcoming, and nothing is to be gained to the present purpose from stopping to inquire into the plausibility of the various attempts that have been made.

Confronting us on the one hand are the evidences of a nitrogen cycle established, seemingly, without affording any visible loophole of opportunity for the accumulation of extensive deposits; on the other hand stands the bare fact of enormous deposition. This fact of existence unquestionably carries with it the possibility of duplication elsewhere. However, the fact of occurrence merely suggests the possibility, but does not determine the chances of recurrence. These are recorded in the prevalence of the conditions requisite to extensive deposition. In the case of nitrogen they are unique beyond comprehension, and the prospect of recurrence is to precisely the same degree unlikely. Accordingly, to all practical purposes, a review of the world's nitrate ore deposits, both real and potential, resolves itself down to a review of the Chilean occurrence.

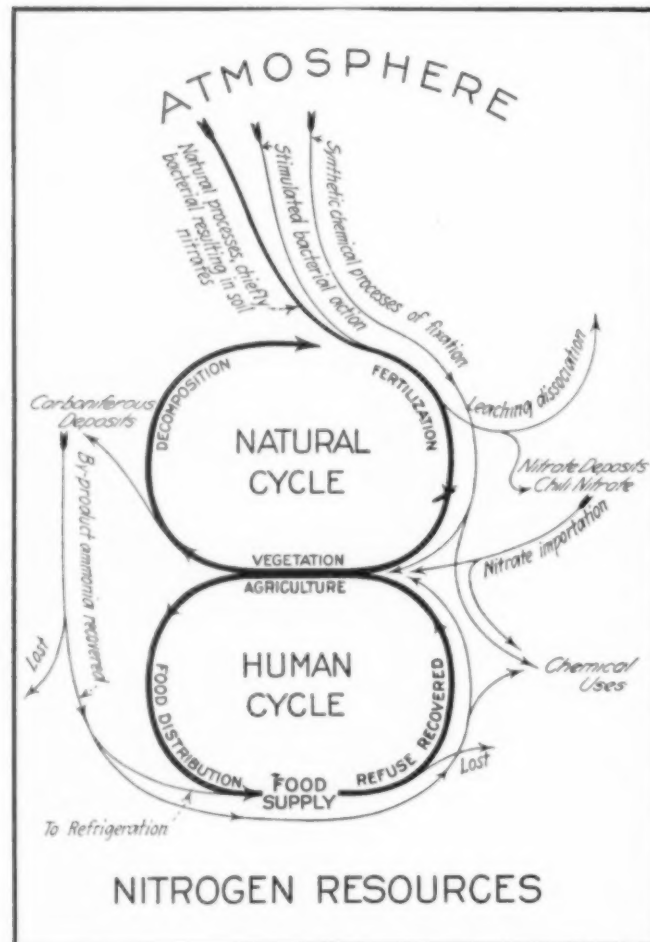


FIG. 1. GRAPH OF THE NITROGEN SITUATION

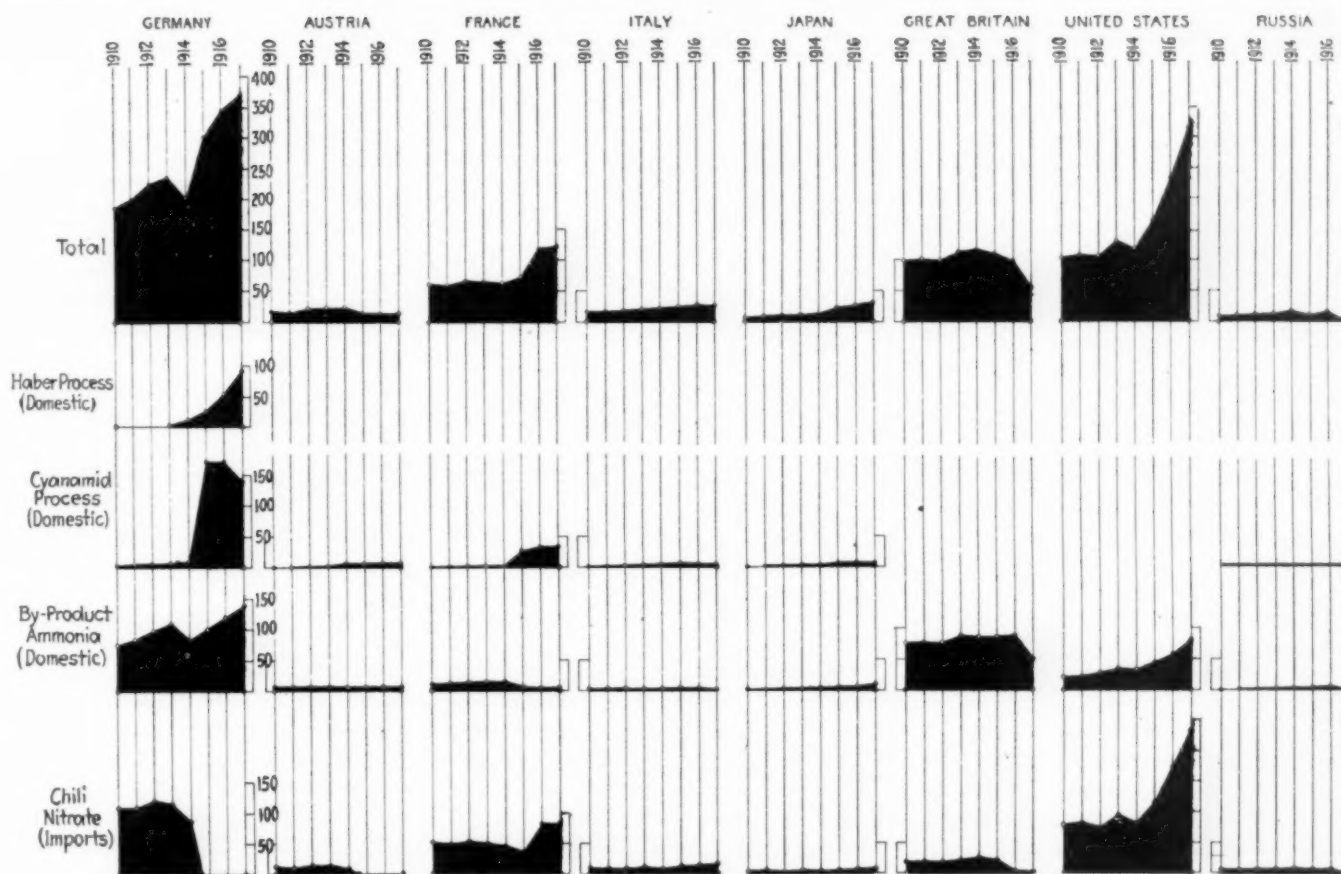


FIG. 2. WAR-TIME DEVELOPMENTS IN THE PRODUCTION OF NITROGEN—FIGURES IN THOUSAND TONS

The Chilean nitrate fields lie in the arid valley basin to the east of the lofty coast range and just south of the present Peruvian boundary line. They do not occur as a single expansive area of deposition, but as deposits scattered here and there along the desert land at the bases of the mountain slopes. The formation consists of a conglomerate or breccia of rock material from the adjacent slopes cemented with a mixture of soluble salts in which sodium chloride, common salt, is the dominant member, with sodium nitrate ranking second. The formation is called caliche. It lies for the most part just below the surface of the ground and varies from a few feet to many feet in thickness. Only in scattered patches is the caliche high enough in content of sodium nitrate to warrant treatment. These patches are sought out and excavated, and the picked ore is loaded in carts which haul it to the extraction plant for treatment. Here the soluble salts as a whole are extracted in solution, and the nitrate in turn is segregated from the other salts by crystallization. Aside from haulage, hand labor is used throughout.

The caliche regarded as worth treating contains not less than 10 per cent and ranges up to 25 per cent and over, with an average of around 18 per cent. The product marketed is of two general grades—the ordinary, listed as 95 per cent nitrate, and the refined, a guaranteed 96 per cent nitrate low in sodium chloride. The deposits have been worked more or less consistently and with steadily increasing output since about 1830. Their importance in the scheme of nitrogen supply may be gathered from Table I and Figs. 2, 3 and 4.

Organic Nitrogen

Another source of fixed nitrogen grows out of its relationship to life processes, and is consequent on the very requirements of organized society which earlier it

is called upon to assist in meeting. In other words, fixed nitrogen participates in the material cycle of life. It enters into the material demands of life for food, and it is yielded up among the material discards available to absorption. All manner of residuum, animal and vegetable alike, affords at least a potential source of fixed-nitrogen supply. Some of these are in service; others for one reason or another are not. Prominent among those in the former class are animal excreta, the so-called tankage from animal-rendering plants, slaughter-house refuse, fish scrap, and vegetable product refinery refuse. Most prominent among those still largely potential are sewage and garbage disposal.

IMPORTANCE OF ORGANIC NITROGEN

The nitrogen from these organic sources does not appear on the market as such. Instead, the products enter in bulk into the make-up of fertilizer. They are of miscellaneous character, and only part of what is contributed collects to pass through industrial channels where its flow may be measured. The industrial flow goes on record and the records are available, but even here the nitrogen content has never been systematically computed, so the record is inadequate. For the rest, the portion that does not reach the channels of industry, there is nothing whatever in the way of data to go by.

Taken all in all, then, the significance of the organic nitrogen resources is largely conjectural. This is unfortunate. The production is so diversified and distributive that anything like exactitude of statistical data would be impossible of compilation, but there is no justification in this for the assumption that nothing is to be gained. Approximate figures covering the use of organic nitrogen would be of value in various connections, as in the interests of intelligent allocation in times of nitrogen shortage, as helping to determine the

extent to which the growing demands of agriculture incident to the growth of population may be discounted from the consequent expansion of scavenging opportunity, or as affording a basis for estimating the very considerable influence of motorization toward increasing the demand for chemically prepared fertilizers.

As things stand, all such questions of relationship lead only to profitless speculation. Even the relative importance of the organic sources as a whole in the economics of nitrogen supply is uncertain. What they have to offer of undeveloped reserves now taking the form of wasteful sanitation procedure will be taken up later. Under existing conditions, it is probably fair to assume that 40 to 50 per cent of the nitrogen normally put to use in the United States is organically associated.

Carboniferous Deposits

Nitrogen in its organic relationships is bound up with carbon, of which organic matter is largely composed, and the bond between the two is entirely disestablished only as the carbon itself loses its substantial form through oxidation. In consequence of this enduring alliance, nitrogen is characteristically present in carboniferous deposits, a form of occurrence giving rise to still another, a fourth type of nitrogen resource. Coal and oil shale loom up as the outstanding representatives of this class. In each, the nitrogen content is variable, but amounts to 1 per cent or over.

With so low a percentage of nitrogen, it goes without saying that neither of these is to be regarded as a possible source of direct supply. The cost would be prohibitive, even under the stress of the most extreme emergency. The nitrogen in a coal bed or an oil-shale formation is as worthless as the iron in any ordinary rock. But coal has other uses, and so has oil shale, or at least will shortly. The nitrogen does not have to be extracted; it gets released incidentally, and when its release is effected under conditions that prevent its

escape, the result is a productive nitrogen resource. The nitrogen from this type of resource is in the form of ammonia, the relative importance of which is shown in Table I and Figs. 2, 3 and 4.

General Aspects of Control of Nitrogen Resources

The nitrogen resource situation as a whole is represented graphically in Fig. 1. Its sources are animal, vegetable, mineral and atmospheric, which is to say, universal, and out of this unparalleled diversity has grown an industrial development as complex as it is diversified, and, incidentally, in view of its bearing on food and munitions supply, as important as it is complex. The situation at best can be but imperfectly grasped, for it has been but inadequately studied. In transgressing all set rules of resource occurrence, it transgresses the limits set for organized investigation. Geologists have studied one phase of the situation, electrochemists another, sanitation experts another, and so on; and the various commercial interests involved have seen to the giving of publicity where publicity would do the most good.

COMPOSITE ECONOMIC SITUATION

An investigation working on the basis of geology alone cannot cope with the situation; neither can one on the basis of technology alone; nor one on the basis of organic chemistry, or bacteriology alone; nor yet one prepared to employ any or all of these means but only with a view to some special end. Nor yet again does the discordant grinding of many axes make a noise from which it is possible to gather an adequate comprehension. The nitrogen situation has been inadequately treated because it has been inadequately studied. It has been studied piecemeal, always through the medium of limited means or with some special end in view.

It is not a series of technical problems in geology, in

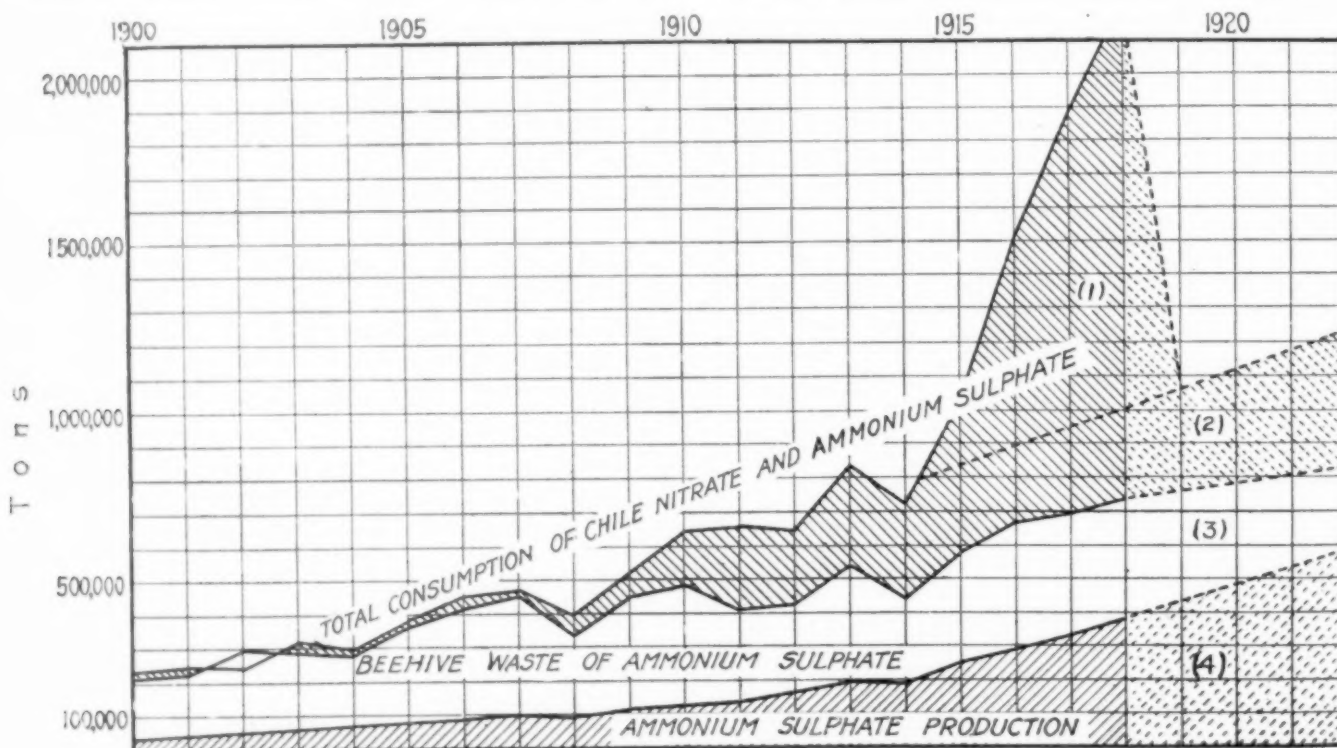


FIG. 3. NITROGEN DEVELOPMENTS IN THE UNITED STATES

(1) War-time expansion for munitions manufacture. (2) Field of competitive opportunity indicated for Chilean nitrate, air nitrate fixation, improved coal fuel practice, shale-oil ammonia, bacterial fixation, imposed sanitation, etc. (3) Field of opportunity reserved to coke-oven recovery. (4) Developments indicated for coke-oven recovery.

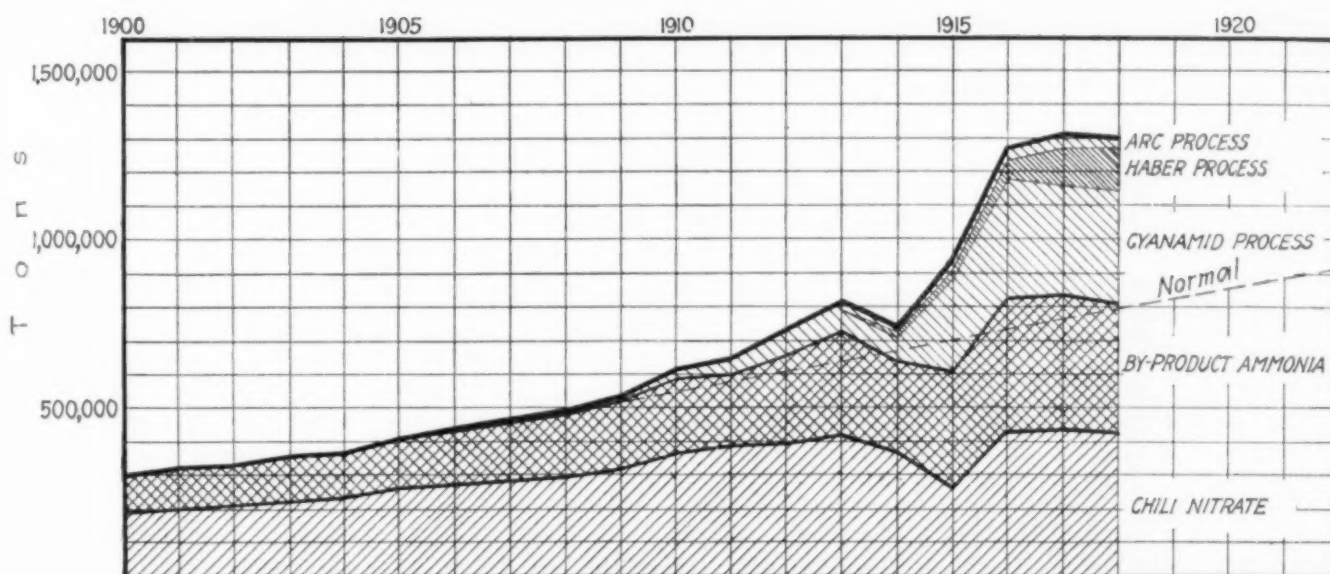


FIG. 4. NITROGEN DEVELOPMENTS FOR THE WORLD, 1900-1918

bacteriology, in fixation, in munitions supply, and the like. It has to do with a composite economic structure building for the dependence of society in peace and war alike. Until treated as such, the needs of the situation are bound to be inadequately met and its control a matter of perilous uncertainty. The present discussion makes no pretense of supplying this deficiency or of doing much of anything more than to show the extent to which it exists.

CONTROL OF NITROGEN RESOURCES

Fig. 1 is designed to show not so much the scope of the resources as their composite functioning in the system of nitrogen supply. The influence of geography in the control of resources so universally available is bound to be subordinate. True, it enables Chile to exercise monopolistic control over the mineral nitrate supply, but it leaves the way open for the development of others; and while acknowledging the fullness of our dependence as shown in Table I and Figs. 2 and 3, we must not lose sight of the fact that it is so not of necessity but because we have been content to leave it so rather than undertake to develop supplies of our own.

So, too, with political control; what is gained in one direction is, potentially at least, offset by the possibilities opening up in others. Control of the sea gives a control over the mineral nitrate supply as absolute as that in Chile's territorial monopoly. Yet in the recent great war Germany, with her shipping obliterated at the outset, was not made to suffer materially from a nitrogen shortage. Britain's supremacy of the sea went for naught. In the years before the war the force due in season to exercise control over the nitrate supply served only to stimulate the development of domestic potentialities, with the result that when the test came Germany's proved actually to be the more advantageous equipment.

Control over the nitrogen resources themselves is impossible. They are too universally available. Their only susceptibility to control is in the shaping of their development. This is too important a matter to be disregarded with impunity and left to develop without guidance. The modern nation that does so courts the irrepressible disaster of a nation at war but bereft of the means not only of waging war but of maintaining a food supply as well.

From Fig. 2 may be gathered the quality of attention given the matter of domestic supply by the different nations immediately before and during the war.

Germany, it will be observed, heeded the call to give the matter special attention well before the war and had an independent system of supply developed in readiness drawing upon the atmosphere and coal product nitrogen, with the results already chronicled.

Great Britain did not ignore the importance of nitrogen, but placed reliance on her supremacy of the sea and paid little or no attention to shaping the course of developments. Nor did its importance go unheeded elsewhere abroad, and the foothold gained for fixation in France, Italy, Austria, Russia and Japan was, it is safe to say, not wholly automatic.

The United States alone among the great nations up to the outbreak of hostilities in Europe in 1914 neglected to take any special precautions whatever.

WAR'S SPECIAL REQUIREMENTS FOR NITROGEN

The war, when it came, far exceeded all expectations as to magnitude, and so in consequence did the demand for specially developed nitrogen supplies. To meet the emergency some could be deflected from agricultural channels, but nothing like what was required, for food was just as important as munitions. The organic sources offered no help. Rather they were a hindrance; for organic nitrogen, broadly speaking, comes as a by-product of sanitation, and as such develops as the outgrowth of civilization's refinements. There was a measurable response from the carboniferous sources, but these could not be made to meet the emergency, for, being of byproduct order, the supply is determined not in response to the demand for nitrogen but for the major products. Dependence on the native mineral source in Chile was out of the question, or at least precarious for any country except Great Britain. Accordingly, of the four great sources it remained for atmospheric nitrogen to meet the emergency. Thus, the war, in bringing the nitrogen situation emphatically to the fore, communicated practically the whole weight of its tremendous impetus to development in the one direction of fixation. The result is shown in Fig. 4.

Roused by the nightmare of war in 1914, even the United States awoke to the perils if not to the real needs of the domestic situation. It is a striking and

highly significant fact that despite the fundamental importance of nitrogen, the awakening found us absolutely without any formulated program of action, even military or agricultural, let alone anything of comprehensive economic scope.

A hysterical effort at improvising a program ensued. We were not yet in the war, and public interest was just roused to the gullible stage. The opportunity for private pickings from public favors was too promising to go by the board. The only prospect opening up lay in the direction of fixation developments, and fixation in the hands of the promoter is one of the most appealing propositions imaginable. Its major requirements are nitrogen and power. With the former inexhaustibly present in the air and the latter inexhaustibly available in the wasting water powers of the country, nothing, it would seem, could offer greater promise. Add to this the reflection that cheap nitrogen means cheap fertilizer, and cheap fertilizer means lowered cost of foodstuffs, and the proposition broadcasted over the country is complete.

Out of the confusion of interests, public, political, and private, a program was finally evolved following our entry into the war calling for the erection of a series of fixation plants with an aggregate producing capacity of around 85,000 tons of fixed nitrogen annually. For a detailed description of these plants the reader must be referred in the interests of brevity to the Bibliography. For the present it must suffice that the war ended before any of these had reached the producing stage, and the United States, like Great Britain, depended on imports.

INFLUENCE OF WAR ON THE DEVELOPMENT OF A NITROGEN INDUSTRY

Fig. 2 shows the influence of the war in the development of nitrogen distributively among the countries concerned. The Scandinavian developments, while actuated from wholly commercial motives, were so largely influenced by the politically stimulated market that they may well enough be included in that general class of politically controlled developments. The same is true for the neutral countries in general.

Fig. 4, based on the best information obtainable, is designed to show the collective influence of the war in contributing to the world's supply. Organic nitrogen is disregarded both because it involves too many uncertainties and because the war-time emphasis was all in the direction of chemical nitrogen. The data in Fig. 2 take into consideration only the actual production and leave out what was in process of construction when the war ended. Accordingly, while in one respect Fig. 2 overrates the effect of the war by including strictly commercial operations that very possibly might have transpired anyway, in another it underrates the situation by disregarding developments like those in this country. The best that can be done is to consider these as balancing each other, which, all things considered, is probably fair enough for all practical purposes. Taken on this basis, the net effect of the war, it will be observed, was to swell the production of fixed nitrogen about 40 or 50 per cent above the figures indicated for the normal rate of expansion.

PEACE-TIME NEEDS OF NITROGEN

Thus the war-time shortage was made up; but all this is history. Now that the war is over, the question arises as to whether the world is due to face the situ-

ation in reverse. In making ready for war, and finally in meeting its demands, has the world been building up a 50 per cent overproduction beyond the needs of peace? Offhand, the answer would seem to be in the affirmative, but the question is not one that can be answered offhand. Agriculture is capable of absorbing an indefinite amount of nitrogen, and the war has wrought a lasting change in the agricultural situation. The changed agricultural conditions make room for much, perhaps for all, of the increment to nitrogen production. The development cannot be sustained, however, on its present arbitrary preferential basis of political expediency. Least of all can it be sustained on that basis in this country. Normally, we do not and cannot be made to think in terms of war. The reason is evident enough, and its recurrent force is already apparent. Distasteful as the fact may be in some of its extremes of application, the only rational procedure is to accept it and fashion our measures of economic preparedness so that the normal activities of peace will keep our economic forces exercised and in trim for the test of war. It was recognized all along before the war that without an assured source of nitrogen supply, our system of defense was hollow; but we succeeded in building up no means of supply in direct response to political needs. We managed to get comfortably started during the war, but it remains to be seen to what extent this artificially nourished development is fitted to withstand the bitter strife of competition ahead.

Part II, dealing with the commercial aspects of nitrogen control and recent developments and changes in practice will be published in our next issue.

Ample Supply of Chilean Nitrate Assured

Sufficient tonnage has been placed in the nitrate trade by the Shipping Board to insure an ample supply of Chilean nitrate to meet fertilizer demands during the coming season. Few deliveries will be made during March, but a sufficient number of ships has been allocated to insure large deliveries during April, May and June. The allocation of ships was arranged after a careful study of the situation by representatives of the Shipping Board and of the Bureau of Soils.

Bureau of Chemistry Appropriation

The total appropriation allowed the Bureau of Chemistry in the agricultural appropriation bill, as it passed the House, was \$1,321,591. The general salary account totals \$426,190. Other items forming a part of the appropriation are as follows: Biological investigation of food, \$66,400; chemical investigations for other departments, \$14,000; to carry into effect the provisions of the food and drug act, \$579,361; naval stores investigation, \$10,000; insecticide investigation, \$20,000.

Metric System Bill

Hearings are to begin in the near future before the Committee on Coinage, Weights and Measures of the House of Representatives on a bill making the use of the metric system compulsory by the Government departments. The exact provisions of the bill have not been announced. Representative Vestal of Indiana, chairman of the committee, has been assisting in the drafting of the bill, but as yet the draft has not been perfected. Mr. Vestal states, however, that the bill will be introduced shortly.

The Requirements of Refined Copper

A Discussion of the Market Requirements of Refined Copper as to Electrical Conductivity, Pitch, Ductility, Casting and Dimension, Together With Notes as to the Effect of Analysis, Manipulation and Metallurgical Practice on These Characteristics

BY LAWRENCE ADDICKS*

IN ORDER to satisfy market requirements, prime electrolytic copper wirebars and cakes must possess high electrical conductivity, sufficient ductility and physical soundness. From the refiner's point of view the product must also be free from commercial quantities of precious metals. Ingots are given a little more leeway in conductivity and relieved of restrictions as to soundness, inasmuch as they are intended for remelting.

This general subject may advantageously be discussed under the headings of conductivity, pitch, ductility, casting and dimensions.

ELECTRICAL CONDUCTIVITY

It has come to be generally assumed that if a wirebar is a sound casting and a sample of the copper drawn into wire shows a satisfactory conductivity, the product may be accepted as prime electrolytic (or lake) copper. This assumption is not strictly true, as will be shown later, but inasmuch as the preparation of the sample of wire for testing in itself demonstrates within certain limits the ductility of the copper, as the test may be easily and quickly made and as no other test appears to be of general application, conductivity will probably remain as the chief criterion of commercial copper.

Impurities in copper may be divided into three groups as regards their effect upon conductivity: Those which are insoluble in copper, those which are partially soluble and those which are completely soluble—remembering that we are interested only in mixtures where copper enormously predominates.

The elements which are insoluble can evidently have but little effect upon the conductivity, inasmuch as the total quantity of any one impurity is always far below 0.1 per cent and the impurity itself has a certain specific conductivity.

The class which is partially soluble exerts a very marked depression on the conductivity, as such elements form low melting point alloys with copper which crystallize out as eutectics, forming a matrix surrounding crystals of copper like the mortar joints of a mosaic. This matrix may be quite bulky, as part of the copper is added to the quantity of impurity present.

The few elements, such as silver, that form solid solutions with copper have a relatively mild effect upon the conductivity, which is quite negligible in view of the small quantities present.

About fifteen years ago the writer conducted a systematic investigation into the relation between impurities and copper (*Transactions, American Institute of Mining Engineers*, vol. 36, p. 18). Each element in question was added in varying amounts to crucible melts of high-grade copper wire and the conductivity of an annealed sample of wire drawn from the cast compared with the

assay of the same wire for the impurity added. The results of this work are grouped together in Fig. 1.

It will be noted at once that the elements which are known to make copper brittle, such as lead, bismuth and tellurium, have but slight effect upon the conductivity, while those which make excellent bronzes, such as phosphorus, aluminum and silicon, have caused a marked depression. It is difficult, however, to make any practical application of these results, because the presence of one impurity often neutralizes the effect of another, and copper which would be expected to be of indifferent quality based upon these figures may prove to be excellent. This is the reason that chemical analysis, apart from the difficulties attending the accurate determination of traces of impurities, has proved of little value in judging copper as compared with the more practical test of forging and drawing followed by a measurement of conductivity.

By common consent conductivity has come to be expressed in percentage of the value of 0.141729 international ohm at 0 deg. C. found by Matthiessen for a meter-gram of supposedly pure copper over fifty years

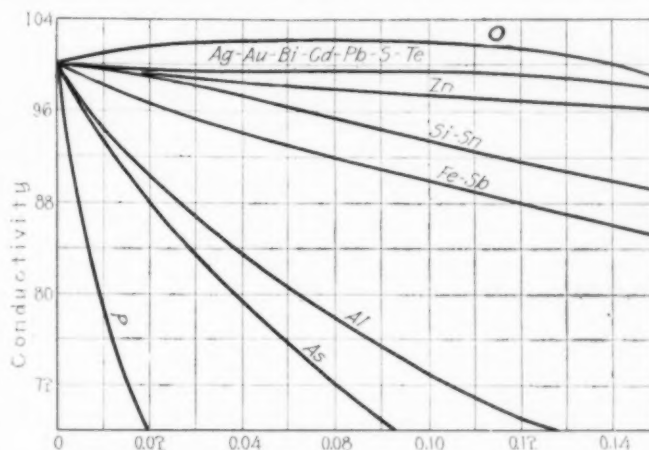


FIG. 1. EFFECT OF IMPURITIES ON CONDUCTIVITY

ago. The specifications of the American Society for Testing Materials have established a minimum requirement equivalent to 98.5 per cent for wirebars and cakes and 97.5 per cent for ingots, determinations being made upon annealed samples. Average copper on the market runs considerably higher than these figures, much of it being over 100 per cent as compared with the imperfectly purified standard copper of Matthiessen. The purest cathode copper—that is, an annealed sample of wire drawn directly from a cathode without melting—may run over 102 per cent; it is unusual, however, for copper that has been melted to run over 101 per cent. The lowering of conductivity by melting is due chiefly to the fact that much of the impurity content of the cathode is present merely as mechanical contamination,

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a certain proportion of which a melting will incorporate chemically. Then there is always the smaller opportunity for the copper to absorb impurities from outside sources during furnace refining.

In drawing copper into wire the coarse crystalline structure of cast copper is broken down into a fibrous structure much harder and stronger but of a lower electrical conductivity, due perhaps to a rearrangement of the system of series-parallel circuits made by copper crystals and matrix. The depression of conductivity bears a direct relation to the degree of hardness attained, as shown in Figs. 2, 3 and 4. (See Addicks, *Transactions, American Institute of Electrical Engineers*, vol. 22, p. 695.) It will be seen from Figs. 3 and 4 that the softening of a wire by annealing has a progressive character in the exact reverse direction from the hardening by working the metal.

In order to arrive at a definite standard for comparing conductivities, therefore, wire is annealed in order to obliterate the somewhat uncertain effect of hard drawing before a determination is made. On the other hand, either a partial annealing or an overheating or "burning" of the wire will give results below the truth.

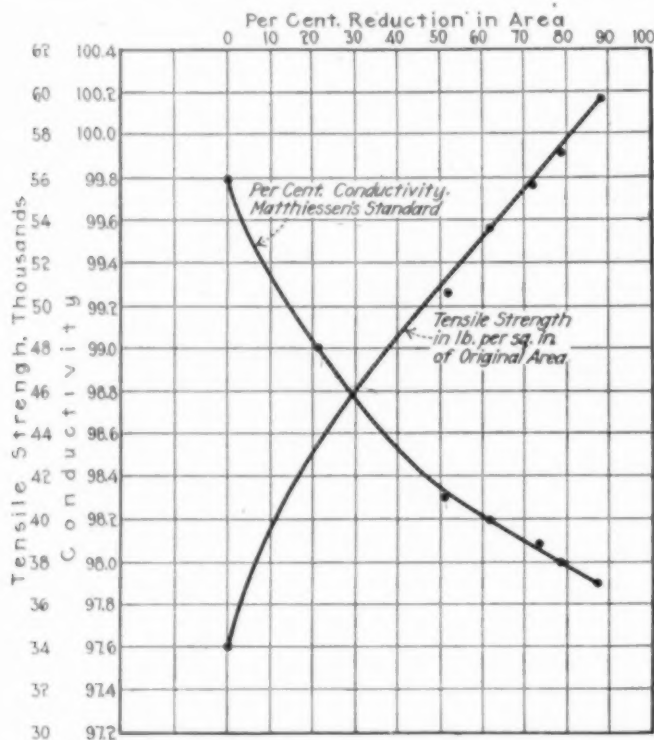


FIG. 2. ANNEALED COPPER ROD OF DIFFERENT SIZES DRAWN TO NO. 12 B. & S.

It is therefore necessary to bring the wire to incipient red heat (about 900 deg. F., or 480 deg. C.) for a brief time in order to get consistent results. All errors, however, are on the safe side, as it is impossible to get unduly high conductivity figures by faulty manipulation.

PITCH OR SET

The pitch, or set, of copper is an expression used to define the appearance of the free surface of a cast copper bar; that is, the bar may be of high, normal or low pitch or it may be "in set" or "out of set."

Molten copper readily dissolves the various gases with which it is brought in contact in the refining furnace, such as oxygen, carbon monoxide and dioxide, and sulphur dioxide. As the copper cools and sets in the

mold excess gas is given off, and the proper control of this phenomenon is the secret of good furnace refining. As has been outlined in a previous article ("The Furnace Refining of Copper," *METALLURGICAL & CHEMICAL ENGINEERING*, vol. 17, p. 579), the bath after melting is allowed to oxidize and the resulting cuprous oxide dissolves and acts as a scorifying agent, the scoria is

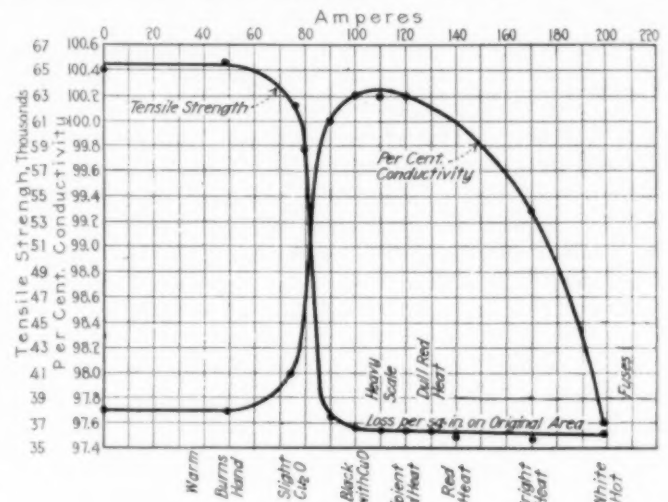


FIG. 3. ELECTRICAL ANNEALING OF NO. 12 B. & S. COPPER WIRE

skimmed off and the excess cuprous oxide reduced by poling. A button of copper cast in a "say-ladle" gives a characteristic set surface and fracture for each stage, the finished product showing a slightly swelling surface without deep wrinkles and a rose-red silken fracture. Should the poling not be carried far enough, the set surface will show a depression and the metal will be hard and somewhat sonorous. Metallographic examination will show thick veins of cuprous oxide eutectic, and careful inspection of the depressed set will reveal "niggerheads," or minute entrances to considerable cavities within. Fig. 5 shows a low set bar which has been planed to show a longitudinal cross-section, and one or two of these cavities are plainly shown. Such a bar may show red shortness in rolling or merely a slight hardness, but the cavities will roll out into small "cold sets" and are probably the main cause of splinters and slivers frequently met with in wire drawing. This phenomenon is identical with "piping" in steel and brass, which are always cast on end, the set surface being sheared off and rejected. Casting of copper on end has been advocated but never generally adopted except in the case of wedge cakes used for purposes where a special mirror polish is required in the rolled article and certain special shapes such as round billets.

If, on the other hand, poling is pushed too far, a reverse condition sets in. The surface bulges on setting and finally "spews over," throwing out worm-like excrescences; some excellent photographs of this condition are given by Hofman, Hayden and Hallowell, *Transactions, American Institute of Mining Engineers*, vol. 38, p. 175. This is analogous to the well-known "spitting" of silver. Such a bar shows perfect softness and malleability in rolling, but the worms have to be chipped off, and overpoled copper is not a satisfactory product. In general, however, the best pitch is one as high as consistent with the avoidance of overpoling.

Overpoled copper shows a slight depression in conductivity, as may be seen from the curve marked oxy-

gen in Fig. 1. The microscope shows the formation of some compound, presumably involving the gases of reduction or possibly sulphur. The latter element is present as included electrolyte in the cathode and in the products of furnace combustion, and until the sulphur has been worked out a charge of blister copper in an anode furnace will give a test button which will "throw a worm" quite similar to that of overpoled copper. Cases of mysterious aging and season cracking in brass have been traced to traces of sulphur, and it must be remembered that lake copper, which had at one time a special reputation in the manufacture of cartridge brass, did not enter the refining furnace with the possibility of faulty separation from a sulphate electrolyte in its past history.

An overpoled charge of copper exhibits instability of pitch, and the mere exposure to the air long enough to restore its depleted oxygen content is not sufficient

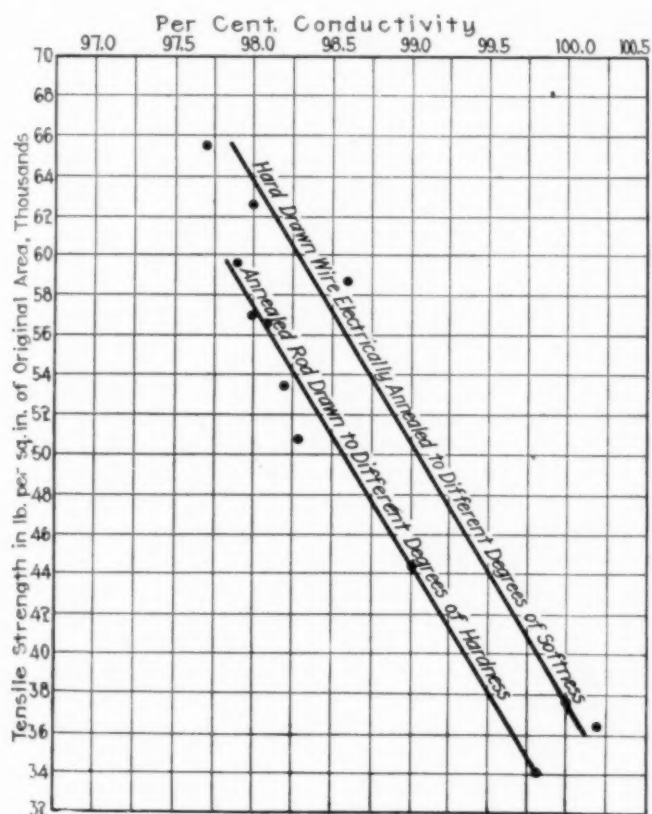


FIG. 4. RELATION BETWEEN CONDUCTIVITY AND TENSILE STRENGTH IN COPPER WIRE

to stabilize this wabby pitch. It is, therefore, necessary to rescorify the entire charge, another indication that a new compound is formed in overpoling. Curiously enough, the addition of a minute proportion of metallic lead to an overpoled charge will stabilize it, but there is great danger of making the copper brittle. This corrective influence might also point to the presence of sulphur, inasmuch as while lead is insoluble in copper, leady copper matte is readily formed, and under special conditions lead and copper can be made to unite as they do in Allan's metal and in many Oriental bronzes.

The reason that foundries have such difficulty in making sound, high-conductivity castings of pure copper is that they get the copper badly below pitch in melting, so that they find it necessary to add various deoxidizing agents. Much phosphor bronze is nearly pure copper,

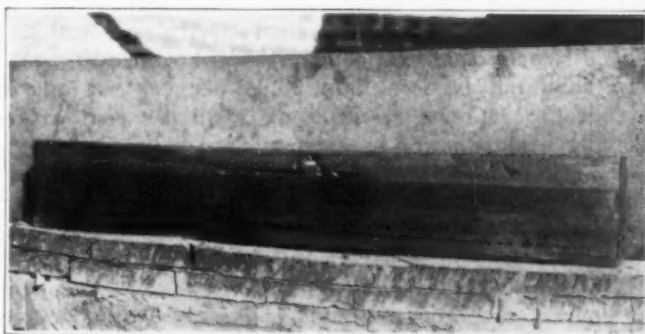


FIG. 5. GAS CAVITIES IN IMPROPERLY REFINED BARS

the phosphorus having vanished as volatile phosphorus pentoxide and merely served as a substitute for poling.

Copper which contains a considerable proportion of some other element—as in the case of arsenical lake running 0.5 per cent arsenic—will show a much coarser wrinkling of the set surface and to the practiced eye has quite a different appearance from pure copper. In the same way copper which has been poled with oil presents a peculiar appearance. Low set copper has heavy wrinkles and may cause cold sets in rolling.

Bars which break in the rolls are frequently found to possess a large cavity near the upper center as shown in Fig. 6, due to a lowness of set. A perfect set should be high and rounding like a mercury meniscus and not show a low level center and a high edge close to the sides where the mold chilled the copper. The wrinkles should be fine and the surface solid.

The set surface carries somewhat more dissolved oxide than the body of the bar. In Europe it was at one time the custom to plane this surface off before rolling when difficult specifications had to be met.

DUCTILITY

While it is known that the addition of exceedingly small quantities of certain elements, such as lead, bismuth or tellurium, will make copper so red-short as to fall to pieces in rolling, it is quite impossible to state permissible limits of such elements on account of the neutralizing effects or various other impurities which may or may not be present. In general it is safe to say that nearly all troubles from brittleness may be traced to low pitch.

Well-refined high-grade copper can be hot rolled into

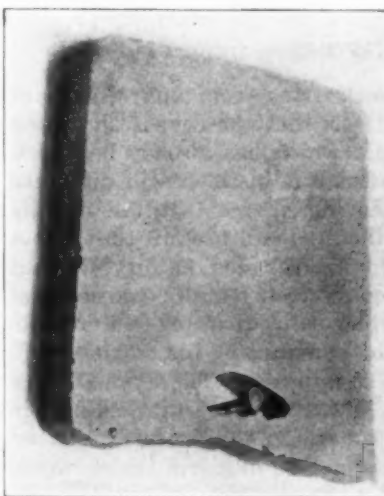


FIG. 6. GAS CAVITY IN LOW SET BAR

quarter-inch rod which after pickling free of scale can be cold drawn into the finest wire without any intermediate annealing. In practice, however, there is always a certain percentage of "breaks" in the wire-drawing machines, and this percentage has been found to bear a direct relation to the copper contents of the lot of wirebars under test. It is, therefore, customary

to impose, in addition to the conductivity specification, a requirement that the copper content (including silver) shall not be less than 99.88 per cent, a figure intended to represent a limit of 99.90 per cent after allowing a margin for assay precision.

The determination of traces of impurities in copper requires long experience. This is particularly true in the case of sulphur, where even the atmosphere of the laboratory must be free from sulphur compounds.

Mechanical tests on samples of wire as checks upon the character of the raw copper have been abandoned because the fabrication of the wire introduces so many variables. The former tests, as a rule, consisted of measurements of tensile strength and torsion.

TENSILE STRENGTH AND TORSION

The tensile strength of copper wire depends upon the percentage of reduction in area after annealing, the speed and the temperature of drawing. With proper regard to these factors, almost any copper not too brittle to draw can be made to fulfill standard telephone wire specifications as to strength.

The usual torsion test was to determine the number of twists a No. 12 B. & S. (2.05 mm. diameter) hard-drawn wire would stand before snapping. This test is perfectly worthless, because it depends entirely upon the property of the thin skin which forms on wire in drawing. A wire as it comes from the drawbench when put in the testing machine will twist uniformly throughout its length for a few turns and then twist tightly at one point and snap. If the wire is scoured with emery paper or dipped for a moment in nitric acid before twisting, the skin is broken down and before snapping the entire length will coil tightly, giving several times the number of total twists formerly obtainable. This skin is at least in part due to imperfect pickling after rolling, as by the use of a nitric acid instead of sulphuric acid pickle on the rod the number of twists that the wire will stand is greatly increased. Particles of oxide scale are probably rolled into the metal, and sulphuric acid, while it will dissolve oxide, cannot cut metallic copper to reach it.

Sometimes bars are badly overheated in the heating furnace before rolling, and this probably causes absorption of gases and consequent brittleness. Altogether, mechanical tests have been entirely dropped as a check on the quality of the copper as distinguished from the finished wire.

CASTINGS

In order to get a perfect casting from a physical point of view, the first requisite is that the copper should be in correct pitch, a subject which has already been discussed at some length. Small adjustments in pitch are made by adding or removing charcoal at the casting machine ladle. Next, the temperature of the copper must be high enough to insure good fluidity without burning the mold. The mold itself must be warm—that is, slightly above the boiling point of water—in order to avoid any condensation of moisture or too sudden chilling of the copper first striking it. There must be a fine film of a suitable mold wash to prevent sticking and the material used must be free of any volatile matter. The mold must be solid and free of pores which would entrap water; otherwise a spongy casting would result. The copper must flow in quickly but evenly and the casting machine must operate so smoothly that a partially

set bar will be subject to no vibration or jars. The bars must be quenched in water soon after setting and this water must be warm. Finally, the molds must be free of warp and set truly level and filled to a given mark without any attempt at adjustment.

These many small points require very careful supervision at the casting wheel and carelessness in any one detail will give more or less defective product. Bars may be out of size, out of set, porous or contain splashes, fins, cold sets or "fish."

Out-of-size bars result from out-of-level or warped molds, or from careless filling to a wrong level. Too large a bar may result in the production of fins in the rolls, due to crowding. Molds suspended at the ends tend to drop in the middle and pinch at the top center.

Porosity may come from low set or may be due to moisture. It generally follows cold or porous molds or too high a casting temperature. In this connection it may be stated that copper molds turn out superior castings to iron ones, although the latter are more or less in use.

Splashes occur when the copper first strikes the mold, being thin sheets of metal which splash on the sides and freeze. Unless they are knocked off with a suitable tool before they are submerged, they are likely to leave a cold set or unwelded lamination in the bar.

Fins are sharp high edges due to filling the mold too rapidly or to vibration of the casting machine giving a wash to the bar before setting. They must be chiseled off the finished bar or they will be rolled in later.

Cold sets occur in various ways whenever molten copper is allowed to enfold cold splashes, etc. They must be chiseled out or, if extensive, the bar rejected.

Fish are bits of charcoal, nails or other foreign bodies allowed to become incorporated in the casting. They are supposed to be removed by a "fisher" during pouring much as a fly is rescued from a glass of milk.

The color of cast copper depends chiefly upon the time allowed to elapse between pouring and quenching and the temperature of the bosh water. The beautiful ruby shades are due to thin films of the lower oxides, and a slight change from the proper conditions will make bars either brassy or black. Twenty years ago good color was given great importance at the rolling mill, but it has nothing to do with the quality.

DIMENSIONS

Each refinery issues a metal schedule giving the weights and dimensions of the market shapes it produces. This covers wirebars, cakes, ingots, ingotbars and billets. Very large wirebars, very heavy cakes and very large billets cast on end are poured by hand from a crane ladle and the additional cost over machine casting is reflected in a premium charged. Ingotbars are merely three ingots cast end to end in order to bring the weight up to a figure where steamships will accept them without demanding that they be barreled.

No rigid requirement as to regularity of size and weight is required of ingots and ingotbars which are to be remelted. In the case of wirebars, however, the American Society for Testing Materials specifications give a tolerance of 5 per cent in weight and $\frac{1}{4}$ in. in any dimension except that wirebars may vary 1 per cent in length and cakes 3 per cent in any dimension greater than 8 in.

For wirebars, each refinery has its own design and

proportions of point. Different rolling-mill men have such contradictory opinions regarding the relative advantages of slight changes in these matters that it is probable that one design is about as good as another. A long point enters the roll more easily at the first pass, but is apt to leave more scrap. A square cross-section is desirable, because a flat bar is apt to turn over in the rolls when part way through. The first pass is often a box roll and after that diamond and oval alternately.

AMERICAN WIREBAR SIZES

A refinery carries about six sets of standard molds and raises the weight of the bars cast from each set by suitably changing the depth to which the molds are filled within the limits imposed by the necessity of keeping a bar reasonably square in cross-section. An example from practice is shown in Table I.

Bars of 135 lb. and under are commonly used in Europe, but practically not at all in the United States, where the usual demand is between 175 and 225 lb. Very heavy bars, running around 800 lb., are in moderate demand on the Continent for making great lengths of trolley wire without reverting to the American practice of brazing.

Inasmuch as the great demand for power in a rolling mill is in the first two or three passes, the roller would prefer a long bar of small cross-section. This, however, would increase the difficulties in casting and in obtaining sound bars, and developments in this direction are improbable unless it be in connection with castings made on end.

TABLE I. TYPICAL AMERICAN WIREBAR SIZES

Weight, lb.	Length, in.	Depth, in.	Top Width, in.	Bottom Width, in.
135	35½	3½	3½	3¾
175	47½	3½	3½	3½
200	49½	3½	4	3½
225	50	4½	4	3½
250	56	3½	4½	3½
275	55½	4½	4½	4½
300	55½	4½	4½	4½

Cakes are the most troublesome class of castings to make. They have a large set surface and this is rolled out to a mirror-like finish where every flaw is readily seen. Often they are cast on "mixed" rings, so that wirebars are interspersed on the mold ring and, as perfect pitch for a wirebar is not necessarily perfect for a cake, a slight disadvantage results. It is quite impossible to cast a small ingot and a heavy cake from the same ladle without adjustment in pitch, as the shrinkage and gas release conditions are so different in the two cases.

Occasionally copper is shipped as cathodes in place of ingots. This is a perfectly logical procedure, as the furnace operation is not a true refining and it has been abundantly shown that a cathode really freed from electrolyte can be melted to high-grade copper without any furnace refining whatever. On the other hand, the cathodes must be sheared to a suitable size, they are often brittle and there is always more or less metal loss in transit. Aside from nodules being dropped by the wayside, pieces are easily broken off by thieves. Also cathodes are quite variable in individual quality, while in the refining furnace thousands are averaged together. The result is that ingots still hold their own in the brass trade, although a fair proportion of cathodes are sold on an allowance below the price of wirebar copper.

New York City.

Legal Notes

BY WELLINGTON GUSTIN

What May Be Done Under Contract to Purchase Requirements

The Supreme Court of Pennsylvania has handed down a decision in the case of the Diamond Alkali Co. against the Aetna Explosives Co. The alkali company had filed a bill in equity against the Aetna company for an accounting of profits realized on the resale of soda ash delivered to it by the complainant under a certain contract which constituted the basis of the action. (107 Atlantic, 711.)

The material part of the contract between the parties, and involved in the controversy, after stating mutual promises to sell and buy, was: "Quantity: Buyer's entire requirements during 1916; minimum quantity 180 tons per month and maximum 250 tons monthly."

The kind was to be 58 per cent light soda ash, shipped in carload lots, price \$1 per 100 lb. Buyer was to give seller at least thirty days notice of his requirements for each ensuing month. The agreement closed with these words: "There are no understandings or agreements relative to this contract or its subject matter that are not fully expressed herein."

The case was disposed of in the court below on bill and answer. A decree was rendered ordering the accounting as desired, and the defendant appealed to the Supreme Court.

FINDINGS OF THE LOWER COURT

In the lower court the Chancellor found six facts, but only the third and fifth ones were material in the case on appeal. These findings are:

"Third. The shipments of soda ash, pursuant to orders from defendant, were less than the minimum specified in the agreement."

"Fifth. Defendant purchased and plaintiff delivered soda ash, which defendant did not use in its business as a manufacturer of explosives, and the excess quantity so obtained was sold by the defendant at a profit."

Now, the decree in the lower court was based on this last, the Chancellor construing the contract to be such that defendant could order only such quantities of soda ash between the minimum and maximum limits as were required in the manufacture of explosives.

FINDING OF THE SUPREME COURT

The Supreme Court said that although the concluding clause of the contract states there are no other agreements or understandings, the lower court read into this contract: "Buyer's entire requirements in its business as a manufacturer in 1916." By referring back to the statement as to the contract it will be seen the words used are: "Buyer's entire requirements during 1916." The court said the requirements of its business as a manufacturer during 1916 may not have been 180 tons of soda ash a month, but whether so or not, it was bound by the terms of its contract to take that quantity from the plaintiff. The minimum and maximum quantities fixed in the contract were not merely probable estimates of the quantities which the Aetna company was to take, but were the definite fixed quantities which it could demand and which the alkali company was bound to deliver. The latter was bound to hold itself in readiness to make shipments ordered under the con-

tract, and the former, in turn, was bound to receive the minimum contracted for. (256 Pa., 295.)

Under the lower court's construction of the contract the defendant Aetna company could not resell any portion of the minimum quantity which it was required to take, if it found that the entire quantity was not actually required in its business. The lower court was of the opinion that "if 250 tons monthly was the quantity required to meet defendant's needs, it could have called for delivery of that quantity, but if fifty tons were sufficient, it could not demand more."

The question of the bad faith of defendant was not involved in the controversy. The complainant had simply averred that defendant had ordered soda ash in excess of its requirements in its business of manufacturing explosives and had resold the same; that by so reselling the defendant had perverted the contract. But the Supreme Court said the mutual rights and obligations under the contract were alone involved, and these were that for one year the plaintiff must be prepared to deliver, and the defendant to take, not less than 180 tons of soda ash per month, with the right to demand seventy more each month. In fact, plaintiff furnished less than 180 tons each month, on defendant's orders.

Now, to find the defendant guilty of "perversion" of the contract, the Supreme Court said, words must be written into it in the face of the clearly expressed intention to the contrary of both parties as stated in the concluding clause.

CASE OF HIGHLANDS CHEMICAL CO. VS. MATTHEWS CITED

The court said the reading of words into a contract was attempted in *Highlands Chemical Co. vs. Matthews*, 76 N. Y., 145, where the contract provided that the plaintiff should supply defendant with oil of vitriol for one year, "total amount to be called for during that time to be not more than 10,000 or less than 7,000 carboys." The defendant called for the maximum quantity, which the plaintiff failed to deliver. In a suit to recover for what had been delivered, the defendant claimed as a set-off the difference between the market price and the contract price of what had not been delivered to him. Thereupon the plaintiff attempted to import into the contract words in effect that the acid was to be used in defendant's business, and that therefore he had no right to demand more than was required for that purpose. The Court of Appeals held this could not be done, saying: "The defendant was required to take the minimum amount, whether he needed or desired it for the purposes of his business or not; and the correlative obligation rested upon the plaintiff to deliver any amount within the maximum fixed by the contract, if called for by the defendant. The contract of the plaintiff is not to supply an amount within the limits named, if needed by the defendant in his business. To introduce this qualification would be adding a new term to the contract."

DECISION OF THE SUPREME COURT

Relying on this, the Supreme Court said it was no concern of the plaintiff what defendant may have done with what it was obliged to receive. If the price of the product had fallen it would have been compelled to bear the loss, and the court held that plaintiff had no right to an accounting for profits or for what it did with any of the product delivered to it under the contract. Hence the decree was reversed and dismissed at cost of the plaintiff.

Damages Awarded Infant Employee

In a personal injury case the defendant company had employed the plaintiff to work upon a laundering machine in one of its plants in New Jersey. His specific work was to keep the edge of the goods which were run through the machine from curling or getting folded, as it passed over the rollers. His hand apparently became entangled in the machinery, was drawn in between two of the rollers and was crushed. The workman was under sixteen years of age at the time of the accident, which fact was not known to the company, as the plaintiff had himself represented to the company's superintendent that he was then over sixteen years old.

The plaintiff brought suit upon the common law liability of an employer to compensate an employee for injuries received in his employment by reason of the negligence of the master. Upon trial a verdict was returned for the plaintiff, and the company appealed. (*Lesko vs. Liondale Bleach, Dye & Print Works*, 107 Atlantic, 275.)

EMPLOYEE'S MISREPRESENTATION AS TO AGE IS NO DEFENSE

On its appeal to the New Jersey Supreme Court the company urged that the workmen's compensation act provided the only means by which an injured employee can recover compensation for injuries received in the course of and arising out of, his employment, and that it abrogates the common law liability of the master for such injuries. But the court said this provision of the statute limiting recovery to compensation applies only where the contract of hiring is a valid one, and not where the contract is prohibited by the statute law of the state, as in this case. But the company argued further that where the false representation as to age had been the inducing cause of the employment, the infant employee is estopped from taking advantage of the statute; or, stated in another way, will not be permitted to deny the truthfulness of his statement made as to his age whereby he secured employment.

However, the court held that the doctrine of estoppel had no application where the employment of the infant is in violation of the provisions of the factory act, although the master employing the infant believes the representation to be true.

LAW'S AIM IS TO PROTECT CHILDREN

Another contention for a reversal of the judgment was that the employee assumed the ordinary risk in the normal operation of the machine which resulted in the injury. Now, the court pointed out, the primary purpose of the factory act is to protect all children who are too young to appreciate the dangers arising out of work, and said that when the legislature had distinctly established an age limit under which children shall not be employed, it, in effect, had declared that a child under that age limit does not have the mature judgment, experience and discretion necessary to engage safely in work prohibited by the statute; and, consequently, a boy employed in violation of the legislative mandate is not chargeable with contributory negligence, or with having assumed the risks arising out of that employment.

Lastly, it was urged the verdict was excessive, but the court held the evidence did not justify a reduction. The verdict of the lower court was sustained.

Theoretical Study of Nitrogen Fixation by the Electric Arc—IV

Kinetic Aspects of the Nitrogen-Oxygen Reactions—Effect of the Arc in Dissociating N_2 , O_2 , and NO —Influence of Molecular Vibration Speeds—Probability Law—Concentrations of NO —Principles of the Electric Arc*

By CHARLES P. STEINMETZ

WHILE it is frequently assumed that the production of NO by the arc is merely a thermal effect, due to the high temperature of the arc, already Haber, Koenig and others have expressed the opinion that the nitrifying action of the arc discharge is at least partly a direct electrical effect, and have brought forward experimental evidence showing that under certain conditions arcs may give NO concentration far above those which could be expected by the thermal action. Further evidence for a direct chemical effect in the arc is given by Hayden in the *A. I. E. E. Transactions*, and a report of Dr. Noyes refers to the same possibility of a direct electronic action in nitrification.

My experience with electrical arcs has led me to the opinion that the nitrifying effect of the arc discharge is primarily a direct electrical effect, a dissociation of the gases in the arc stream into free atoms and a recombination of the free atoms into all possible combinations by the probability law, and that the thermal effect is a secondary one, in limiting the amount of NO which can be recovered from the arc.

The electric arc discharge probably is the most powerful dissociating agent, as seen by most chemical compounds in the arc giving the elementary spectra.

The phenomenon of nitrification by the arc then would be as follows:

In the arc stream, that is, the gas column which carries the electric current, the molecules of N_2 and O_2 are dissociated into their free atoms N and O . When leaving the arc stream, or when the arc stream stops by interruption of the current and the electrification action thus is withdrawn, these free atoms recombine, N with N , O with O and N with O , thus giving a mixture of N_2 , O_2 and NO in the proportions determined by the probability law of the atoms meeting each other. If the temperature of the arc stream is so low that the dissociation velocity of NO is negligible, as might probably be the case with the mercury arc or with cadmium and zinc arc, this gas mixture survives; if the temperature of the gases coming from the arc stream is so high that the dissociation velocity is considerable, dissociation of NO occurs, the more the slower the temperature drops.

However, the formation of NO by the probability law from the dissociated gases in the arc stream and the dissociation by the temperature law during the cooling of the gases coming from the hot arc would merely be a theoretical segregation of the two phases of the phenomenon. In reality, when the electrical action of the arc is withdrawn from the mass of hot dissociated gases, N atoms meeting with N atoms will usually com-

bine to N_2 molecules, unless their velocity, that is, temperature, is above the dissociation temperature of N_2 . So O atoms meeting with other O atoms will usually combine to O_2 molecules; but N atoms meeting with O atoms will usually not combine, unless their velocity happens to be low, that is, materially below the average corresponding to the temperature, until the average velocity, that is, the temperature, has fallen sufficiently, for instance by giving off velocity to slow moving molecules, that is, by mixture with cold gases. If then the average velocity, that is, the temperature, falls slowly, before it has fallen sufficiently to permit the formation of many NO molecules, most of the free atoms of N and O will have vanished by combining to N_2 and O_2 molecules. The quicker thus the cooling of the hot mixture of dissociated gases the more N and O atoms would survive to the temperature where NO can form to any great extent.

The phenomenon thus would be that of the approach to equilibrium conditions of a mixture of N , O , N_2 , O_2 , and NO , from a mixture of N and O produced by the arc. If the arc temperature is very high, and the reaction velocity thus extremely high, it can easily be seen that the condition of thermal equilibrium, by Nernst's equation, preponderates, unless extremely rapid cooling is possible. Only with arcs of relatively low temperature, or extremely rapid cooling (such as is possible with very thin, that is, low current, arcs, which are rapidly and frequently interrupted, as for instance by the Bradley-Lovejoy method of arc nitrification), a material difference in the result may be expected, if the phenomenon is not thermal but electrical. It is under these conditions that abnormally high concentrations, etc., have been observed by Koenig and others.

However, since the Bradley-Lovejoy process was a commercial failure, and the Birkland-Eyde process in Norway a success, at least under the conditions prevailing there, most of the attention of the investigators has since been concentrated on the latter process. In this, however, due to the large high-current high-temperature arc, the thermal phenomenon probably predominates.

Nevertheless, in my opinion, the evidence is strongly in favor of the assumption that the effect in the arc is primarily an electrical one, a dissociation of the molecules into free atoms, and then recombination of these by the probability law, limited by the temperature stability of the resulting products.

Assuming then that a gas mixture like air, consisting of:

n_0 g. mol. N_2

o_0 g. mol. O_2

b g. mol. neutral gases, as A , etc.,

*For Parts I, II and III see *CHEM. & MET. ENG.*, vol. 22, Nos. 7, 8 and 9, Feb. 18 and 25 and March 3, 1920, pp. 299, 353 and 411.

where:

$$n_o + o_o + b = 1$$

is dissociated by the arc, and the free atoms, recombining by the probability law, then from the gas mixture of:

n g. mol. N_2

o g. mol. O_2

a g. mol. NO

b g. mol. neutral gases.

where:

$$n + o + a + b = 1$$

The probability, in the dissociated state, of an N atom meeting another N atom, that is, of two N atoms meeting each other, bears to the probability of an N atom meeting an O atom, the ratio:

$$n \div a = \frac{n_o}{2} \div o_o \quad (101)$$

The probability of an O atom meeting another O atom bears to that of an O atom meeting an N atom the ratio:

$$o \div a = \frac{o_o}{2} \div n_o \quad (102)$$

(101) and (102) give:

$$n \div a \div o = n_o^2 \div 2n_o o_o \div o_o^2 \quad (103)$$

and since

$$n + a + o = n_o + o_o = 1 - b \quad (104)$$

It is:

$$\begin{aligned} a &= \frac{2n_o o_o}{1 - b} \\ n &= \frac{n_o^2}{1 - b} \\ o &= \frac{o_o^2}{1 - b} \end{aligned} \quad (105)$$

which gives:

	Air		1 + 1 Mixture of N_2 and O_2	
	Before Passing the Arc	After Passing the Arc	Before Passing the Arc	After Passing the Arc
N_2 concentration.....	$n_o = 0.777$	$n = 0.6116$	$n_o = 0.50$	$n = 0.25$
O_2 concentration.....	$o_o = 0.210$	$o = 0.0447$	$o_o = 0.50$	$o = 0.25$
NO concentration.....		$a = 0.3307$		$a = 0.50$
Neutrals, concentration b	$b = 0.013$	$b = 0.013$		

According hereto, the air coming from the arc stream would have an equilibrium concentration of NO of about 33 per cent, if the thermal equilibrium concentrations are left entirely out of consideration, as could be done only if the arc temperature is very low. Otherwise the NO concentration will be reduced by dissociation due to the approach to the thermal equilibrium at a rate depending on the initial temperature and the rapidity of the cooling. It probably makes no material, if any, difference if we assume the electrical equilibrium established instantly and the concentration resulting therefrom then reduced by the condition of thermal equilibrium, or if we assume both effects occurring simultaneously, as probably the case, and thus these high concentrations never reached. We may thus use the first assumption, that is, segregating the thermal and the electrical effect, as it allows us to calculate from the initial concentration of the chemical equilibrium, by the laws of thermal equilibrium, the residual NO concentration from the rate of cooling.

DISSOCIATION ACCELERATION CONSTANT

The velocity of thermal dissociation is, by (12):

$$v = -\frac{da}{dt} = c_2 a^2 - c_1 \left(n - \frac{a}{2} \right) \left(o - \frac{a}{2} \right) \quad (106)$$

At concentration a , much above the thermal equilibrium concentration, as would be the case here, the sec-

ond term of equation (106) is negligible, as seen from the table of reaction velocities III. Thus it is:

$$v = \frac{da}{dt} = c_2 a^2 \quad (107)$$

It is then:

$$\frac{dv}{dT} = a^2 \frac{dc_2}{dT} + 2ac_2 \frac{da}{dT}$$

As a is independent of the temperature T , that is, a change of T does not change a except through c_2 , it is:

$$\frac{da}{dT} = 0$$

Thus:

$$\frac{dv}{dT} = a^2 \frac{dc_2}{dT} \quad (108)$$

It is, however, by (23)

$$\log_{10} c = -10.887 + 5.731T \times 10^{-3} \quad (109)$$

or:

$$\log_e c_2 = -25.07 + 13.20T \times 10^{-3} \quad (110)$$

Herefrom follows:

$$\frac{dc_2}{dT} = 13.20 \times 10^{-3} c_2 \quad (111)$$

Substituting (111) into (108) gives:

$$\frac{dv}{dT} = 13.20 \times 10^{-3} a^2 c_2 \quad (112)$$

Substituting (107) into (112) gives:

$$\frac{dv}{dT} = 13.20 \times 10^{-3} v \quad (113)$$

Thus, integrated:

$$\log_e \frac{v}{v_o} = 13.20 \times 10^{-3} (T - T_o) \quad (114)$$

where

v_o and T_o are two corresponding values, or, in common logarithms:

$$\log_{10} \frac{v}{v_o} = 5.731 \times 10^{-3} (T - T_o) \quad (115)$$

That is, for constant temperature intervals $(T - T_o)$, the dissociation-velocity increases by a constant factor.

For $(T - T_o) = 100$, or 100 deg. rise of temperature, $\frac{v}{v_o} = 3.74$ fold, or the action velocity increases 3.74 times; for 200 deg. temperature rise, 14.0 fold.

From (114) follows

$$v = v_o e^{s(T - T_o)} \quad (116)$$

where:

$$s = 13.2 \times 10^{-3} = .0132 \quad (117)$$

Thus:

$$\frac{da}{dt} = -v_o e^{s(T - T_o)} \quad (118)$$

If now the cooling of the gas mixture is carried out by the cooling function:

$$\frac{dT}{dt} = -f(T, t) = -bT^n \quad (119)$$

That is, the gases are cooled proportional to some power of the temperature ($n = 4$: radiation; $n = 1$: conduction, approximately; $n = 0$: constant rate of cooling) it is:

$$\frac{da}{dT} = \frac{da}{dt} \div \frac{dT}{dt} = \frac{v_o e^{s(T - T_o)}}{f(T, t)} = \frac{v_o e^{s(T - T_o)}}{bT^n} \quad (120)$$

Thus, integrated:

$$a_1 - a = \frac{v_o}{b} e^{sT_o} \int_T^{T_1} T^{-n} e^{sT} dT \quad (121)$$

for $n = 0$, or constant rate of cooling, this gives:

$$a_1 - a = \frac{v_0 e^{-sT_0}}{sb} [e^{sT_1} - e^{sT}] \quad (122)$$

If T_1 is the high initial gas temperature, T the much lower final temperature, the second term is negligible compared with the first term, and equation (122) simplifies to:

$$a_1 - a = \frac{V_0}{sb} e^{s(T_1 - T_0)} \quad (123)$$

where a_1 and T_1 are the initial concentration and initial temperature, v_0 the dissociation velocity at temperature T_0 .

Substituting (107)

$$a_1 - a = \frac{c_2 a_0^2}{s b} e^{s(T_1 - T_0)} \quad (124)$$

or, making $T_0 = T_1$, thus $a_0 = a_1$:

$$\frac{a_1 - a}{a_1^2} = \frac{c_2}{sb} \quad (125)$$

and by (110):

$$c_2 = e^{-25.07 + sT_1} \quad (126)$$

Thus:

$$a_1 - a = \frac{a_1^2}{sb} e^{sT_1 - 25.07} \quad (127)$$

$$\begin{aligned} \log_{10} (a_1 - a) &= 2 \log_{10} a_1 - \log_{10} s \log_{10} b + \\ &\quad .4343 sT_1 - 10.887 \\ &= 5.731 \times 10^{-3} T_1 - 10.887 + \\ &\quad 2 \log_{10} a_1 - b - 8.121 \\ &= 5.731 \times 10^{-3} T_1 - \log_{10} b + \\ &\quad 2 \log_{10} a_1 - 9.008 \quad (128) \end{aligned}$$

If:

$$a_1 = .33$$

It is:

$$\begin{aligned} \log_{10} (a_1 - a) + 5.731 \times 10^{-3} T_1 - \log_{10} b - 9.971 \\ \text{or, if } a \text{ and } a_1 \text{ are given in per cent:} \\ \log_{10} (33 - a) = 5.731 \times 10^{-3} T_1 - \log_{10} b - 7.971 \quad (129) \end{aligned}$$

or, approximately:

$$\log_{10} (33 - a) = 5.731 \times 10^{-3} T_1 - \log_{10} b - 8 \quad (130)$$

That is, with an arc temperature or initial temperature T_1 and cooling constant b , starting with the initial concentration of electrical equilibrium of 33 per cent NO, the final concentration a , after cooling at constant rate, to temperatures where the dissociation velocity has become negligible, is given by equation (130).

However, this equation involves the assumption that a is high compared with the equilibrium concentration, and ceases to apply if a approaches the thermal equilibrium concentration. It may be used, however, to determine the range of T and b , within which an appreciable part of the initial concentration $a_1 = 33$ per cent can be saved; outside of this range, the thermal equilibrium conditions prevail.

From (129) follows:

$$T_1 = \frac{\log_{10} (33 - a) + \log_{10} b + 7.971}{5.731} \times 10^3 \quad (131)$$

RESIDUAL CONCENTRATIONS

In Table XIII (see p. 416) are given, for a cooling rate of $b = 10^5$ per sec., the arc temperature T_1 , which gives various residual NO concentrations a , from 0, that is, temperature equilibrium, up to 32.9 per cent. These values are plotted in dotted lines, with the temperature as abscissae, in Fig. 11.

Table XIV gives the arc temperatures required at various cooling rates b , from 1 to 10^8 deg. per sec., to

TABLE XV. EQUILIBRIUM

Average cooling rate: $b = 10^5$ deg. per sec. distributed as follows:
 $b = 10^3 \quad 10^{3.5} \quad 10^4 \quad 10^{4.5} \quad 10^5 \quad 10^{5.5} \quad 10^6 \quad 10^{6.5} \quad 10^7$
 Per cent: 2 7 13 18 20 18 13 7 2 100
 Cooled by air of 400 deg. abs. to temperature of 1400 deg. abs.
 $\log_{10} (33 - a) = 5.731 T_1 10^{-3} - \log_{10} b - 7.971$

Arc Temp. Abs.	A Electro-Thermal		B Thermal	
	In Arc	Per Cent in Gas Mixture	In Arc	Per Cent in Gas Mixture
Below 1400	33.0	33.0	...	...
1400	33.0	33.0	0.06	0.06
1600	33.0	27.5	0.16	0.133
1800	33.0	23.6	0.33	0.236
2000	32.8	20.5	0.61	0.381
2200	30.6	17.0	0.98	0.544
2300	26.7	14.1	...	...
2400	20.9	10.45	1.47	0.735
2500	14.3	6.81	1.74	0.829
2600	8.23	3.74	2.01	0.914
2700	4.26	1.85	2.27	0.987
2800	2.81	1.17	2.42	1.008
2900	...	...	2.51	1.004
3000	2.54	0.98	2.548	0.977
3100	...	...	2.553	0.948
3200	2.55	0.91	2.554	0.912
3400	2.55	0.85	2.554	0.851
3600	2.55	0.80	2.554	0.798
3800	2.55	0.75	2.554	0.751
4000	2.55	0.71	2.554	0.710
4200	2.55	0.67	2.554	0.672
4400	2.55	0.64	2.554	0.638

give various residual concentrations, from $a = 32$ per cent, that is, practically chemical equilibrium, and the thermal effect does not yet come into consideration, up to $a = 0$, that is, the residual concentration is entirely determined by the temperature equilibrium.

These values are plotted in Fig. 13, with the cooling rate b as abscissae and the temperature as ordinates. As seen, at each cooling rate, there is (theoretically) a relatively narrow temperature range of less than 300 deg., in which the effect changes from electrical to thermal. With arc temperatures above this critical range, the effect is entirely thermal; with arc temperatures below this range, it is entirely electrical, while with arcs of a temperature within this range, it is partly thermal, partly electrical. Thus at a cooling rate of $b = 10^5$, at arc temperatures above 2530 deg. abs. the NO concentration entirely depends on the thermal equilibrium; but at an arc temperature of 2460 deg. abs., or only 70 deg. lower, already a concentration of 20 per cent NO, if produced electrically, could survive, while at arc temperatures below 2260 deg. abs., practically the entire electrical equilibrium concentration of NO would survive.

Table XV then gives for an average cooling rate $b = 10^5$, that is, a rate varying for the different parts of the air between 10^3 and 10^7 , the concentration which would result at various arc temperatures, when cooling the gases to 1400 deg. abs., by mixing air at 400 deg. abs., with the arc stream. A, with an electrical equilibrium of 33 per cent NO in the arc stream, B, with the action being entirely thermal.

In Figs. 11 and 12 are plotted the values of the residual concentration of the arc gases, and the concentration of the gas mixture resulting from the arc and the cool air, with the arc temperature as abscissae. Fig. 12 gives the values in a larger scale, for electrical and thermal equilibrium, while Fig. 11 shows only the electrical equilibrium conditions, but shows the critical temperature range, where the action changes

TABLE XIV. ELECTRO-THERMAL EQUILIBRIUM

Cooling rate, deg. per sec.:	$b =$	1	10	10^2	10^3	10^4	10^5	10^6	10^7	10^8
Residual Concentration of NO:	$a = 32$ per cent	1390	1565	1740	1915	2080	2255	2430	2605	2780
	20 per cent	1595	1770	1945	2120	2285	2460	2635	2810	2985
	10 per cent.	1640	1815	1990	2165	2330	2505	2680	2855	3030
	Thermal equilibrium:	1665	1840	2015	2190	2355	2530	2705	2880	3055

from thermal at higher, to electrical at lower temperatures.

It must be realized, however, that this matter of very high concentration in the arc stream, resulting from the probability law, is entirely speculative, and while there is good evidence for the assumption that the nitrifying action of the arc stream is not a mere thermal effect, but that a direct electrical effect comes in, it is not probable that the action is as simple as assumed in the preceding, nor that such high concentrations are reached, and more experimental evidence is necessary before fully understanding the nitrifying action of the electric arc. It is more probable that the concentrations

In the following shall therefore be given a short outline of our knowledge of the physical and other characteristics of electric arcs, as far as known, to serve as a starting point for further research on arcs.

THE NORMAL ARC

In the following we shall limit ourselves to the presentation and discussion of the physical characteristics of the arc, without considering their theoretical explanations by the ionic theory or otherwise.

The typical or normal arc is best illustrated by the passage of a unidirectional continuous current between two terminals, of metal or similar conductors, such as carbon, magnetite, titanium carbide, etc., in an atmosphere of constant pressure, while not disturbed by air currents, external magnetic or electrostatic fields, etc.

The melting point of carbon is above its boiling point at atmospheric pressure. Therefore, when using carbon as arc terminals, no fused spot or pool can form on the terminal, as with other materials in which the

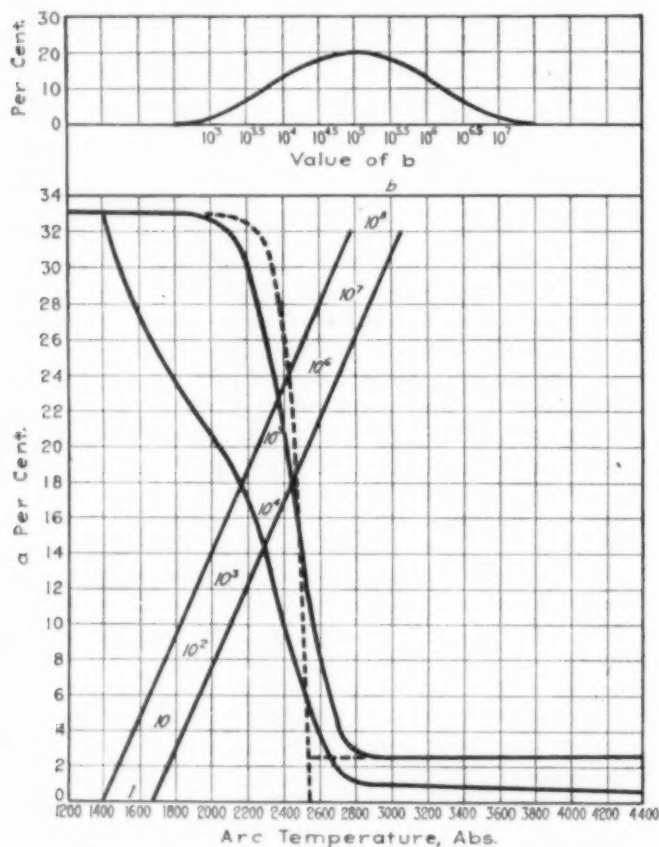


FIG. 11. ELECTRO-THERMAL EQUILIBRIUM NO CONCENTRATION

brought about by direct electrical action are much higher than those of thermal equilibrium, especially at lower arc temperatures, but are still far below the values given by the probability law, as assumed above.

APPENDIX: THE ARC

As seen, the problem of economical, that is, efficient, nitrogen fixation by the electric arc is essentially dependent on the physical and electrochemical characteristics of the electric arc, in the solution of designing the operating conditions such as to produce the maximum amount of electrochemical action with the minimum expenditure of energy in the arc. Unfortunately, our knowledge of the physical and electrochemical characteristics of the various forms and types of electric arcs is still so limited that an intelligent and systematic design of arc nitrification processes for maximum efficiency will not be possible unless very much more is known on the nature of stationary and transient arcs, and before much further advance can be made a systematic research into the electric arc and its properties thus appears essential.

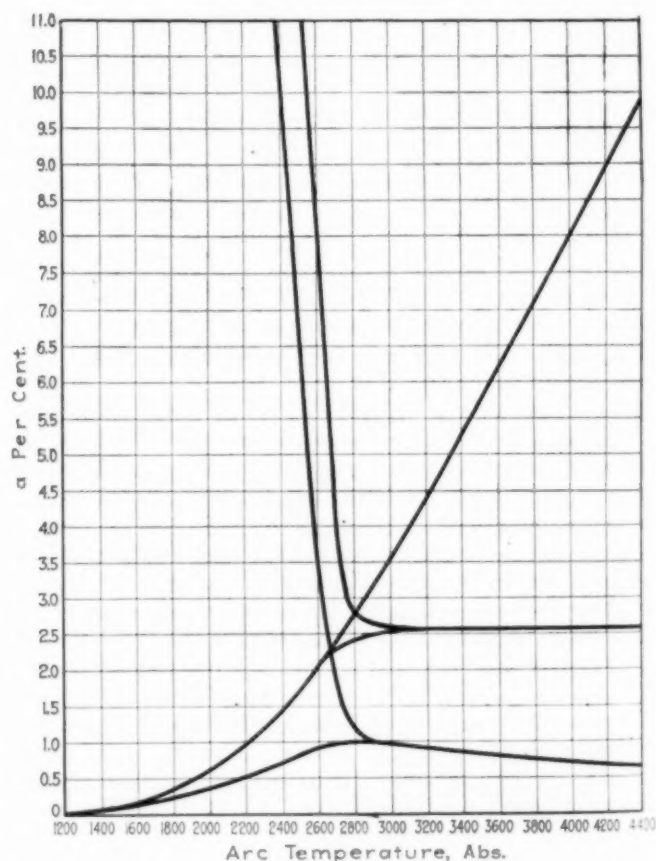


FIG. 12. ELECTRO-THERMAL AND THERMAL EQUILIBRIUM NO CONCENTRATION

melting point is below the boiling point. Also, at the temperature of the boiling point of carbon, the dielectric strength of gases and vapors has decreased so much that they are practically conductors. Therefore, the unidirectional character of arc condition is little pronounced in the carbon arc, and with alternating current supply the momentary interruption of the current at its reversal does not interfere with the arc. In these two characteristics, and the features depending upon them, the carbon arc differs from other typical arcs, so that the carbon arc is not well suited for the study of the characteristics of the typical arc. Well suited for this purpose are the mercury arc and the iron or magnetic arc, as the spectra of these two metals are very

sensitive to the temperature, the relative intensity of their lines greatly changing with the temperature and thereby affording a means of judging of the temperature.

ARC SPECTRUM

The light of the normal arc always shows the spectrum of the cathode material throughout the entire arc length, even if the cathode is strongly cooled. It seems herefrom that the presence of cathode material in the arc stream is necessary for the arc conduction.¹

The spectrum of the anode material generally does not appear in the arc stream. Only if the anode contains material which is much more volatile than the cathode material, and the anode is allowed to become hot, the spectrum of such material appears in the arc stream. But even then it often appears only in that part of the arc stream next to the anode, and does not extend to the cathode, or at least occasionally fades out from the part of the arc stream near the cathode, sometimes with a sharp boundary line where the anode spectrum ends.

The intensity of the spectrum of the anode material in the arc stream is reduced by cooling the anode, or making it so large as not to get very hot, and the anodic spectrum may entirely disappear by cooling, at least from the part of the arc stream nearer the cathode.

It seems herefrom that the presence of anode material in the arc stream is not essential for the arc conduction, but that such material enters the arc stream rather by heat evaporation.

The cathode is gradually consumed by feeding material into the arc stream, and though this consumption of cathode material can be greatly reduced by cooling the cathode (relatively), it can apparently never entirely be eliminated. The consumption of the anode, however, greatly varies with its temperature, and by keeping the anode cool, as by making it larger, the consumption of the anode can not only be entirely suppressed, but the anode made to increase in weight, by the deposition of cathode material on it.

CONTINUITY OF ARC

The arc conduction is continuous, that is, the current must flow continuously, and when once interrupted for even a very short time, the arc ceases and does not start again when the voltage is reapplied, but to restart it by reapplying voltage such voltage must be so high as to jump a static spark across the arc terminals through the gas or vapor existing between them. Thus in general, alternating current arcs cannot be operated at the voltage sufficient to maintain a direct current arc between the same terminals, but go out at the end of the half wave of current. Only when the temperature of the arc stream is so high—as in the carbon arc—that the voltage required to jump the spark across the residual vapor between the electrodes is of the same low magnitude as the voltage required to maintain the arc, alternating arcs can be operated without materially higher voltage than direct current arcs.

The arc can be shifted from one anode to another one, not in contact with the former, by bringing the second

anode into the arc stream. If then the second anode is nearer to the cathode than the former, or is given a higher potential difference against the cathode, the arc leaves the former anode and goes to the latter, either gradually or suddenly, or it may even be made to divide between the two anodes. The arc, therefore, does not need to be continuous at the anode.

A rod of insulating material or even a rod of metal may be passed through the arc stream without disturb-

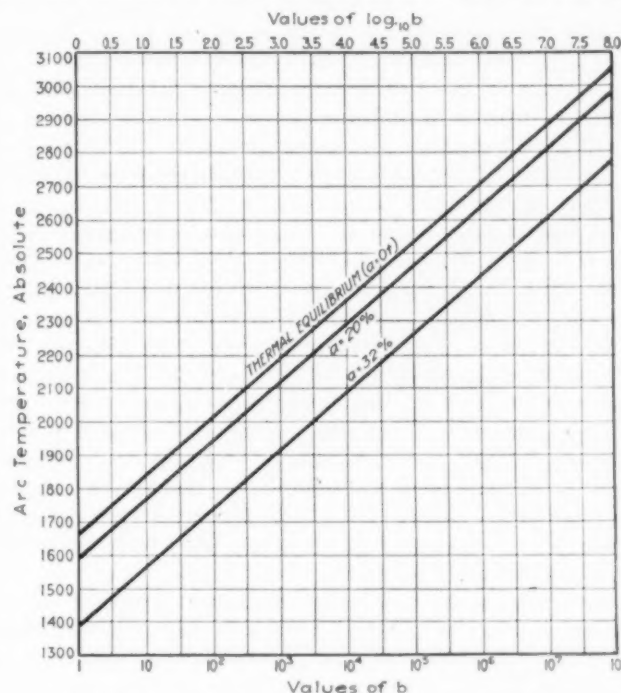


FIG. 13. ELECTRO-THERMAL EQUILIBRIUM

ing it. Thus the arc does not need to be continuous in the stream.

The arc cannot be shifted from one cathode to another one not in contact with the former, by immersing the latter into the arc stream, even if the second cathode is materially nearer to the anode, or of materially higher negative potential difference against the anode, unless the voltage between the second cathode and the anode is so high as to jump a spark and thereby start a new arc; as the spark voltage greatly decreases with the temperature, by immersing a second small cathode into the arc stream, after some time, the arc may jump to it, when the jump spark voltage has decreased by the second cathode becoming sufficiently hot. The arc can shift from one cathode to another one only when the second cathode is in direct contact with the first, and the negative terminal of the arc stream, or the "negative spot," moves continuously from one to the other cathode.

CATHODE STREAM

All these phenomena combined afford a strong evidence that the vapor of the negative terminal is an essential factor in the conduction of the current by the arc between the terminals, or, as it may be expressed, that the "cathode vapor stream," or "negative vapor stream," is the arc conductor which carries the current across the gap between the terminals. This statement, however, involves no assumption on the way the current is conducted, or on the nature of the conduction. The conduction might, for instance, be explained as ionic conduction in which the cathode vapor stream

¹An apparent exception herefrom may occur when the cathode consists of a very refractory material, such as carbon, and the surrounding atmosphere consists of a gas or vapor which is a good arc conductor. Thus a typical mercury arc may be operated between two carbon electrodes in an evacuated space filled with mercury vapor. But even then the cathode disintegrates, and it is rather probable that the arc starts as carbon arcs, but transfers to the mercury vapor. The cathode in this case has the characteristics of the cathode of a carbon arc, and not that of a mercury arc.

plays a similar part as the metal conductor in the passage of the current through a copper wire, except that in the arc conductor, the cathode vapor stream is produced by the current, varies with it, and depends on it, and thus ceases with an interruption of the current.

ARC TEMPERATURE

Usually in the normal arc, by cooling the arc stream near the cathode, the major part of the cathode vapor can be condensed, or by cooling the cathode, the amount of cathode vapor which is produced can be greatly reduced, without appreciably affecting the electrical characteristics of the arc and the nature of its spectrum. Herefrom seems to follow that the amount of vapor produced at the cathode and existing in the arc stream is in the normal arc usually very much greater than the amount required to carry the current.

At constant pressure of the atmosphere surrounding the arc, the spectrum of the cathode vapor stream does not change with the change of current or voltage of the arc, but is the same with long arcs or short arcs, with arcs of small current or large current, though the amount of cathode vapor in the latter is much larger. The spectrum does not change either, if much of the cathode vapor is condensed out of the arc stream by cooling it near the cathode, or cooling the cathode. This is the case even with such arc conductors as mercury or iron vapor, in which the spectrum greatly changes with the temperature; and the spectrum is the low temperature spectrum.

Herefrom seems to follow that the temperature of the arc stream in the normal arc is constant and that at constant pressure of the surrounding atmosphere it depends only on the material of the cathode, and that it is the temperature of the boiling point of the cathode material. With an increase of the gas pressure of the surrounding atmosphere, the spectrum of the cathode stream of the normal arc changes in such manner as it would be changed by an increase of temperature. Thus with the mercury arc, the red lines, which are extremely faint in the mercury arc spectrum at high vacuum, become more prominent.

MERCURY AND IRON ARC

The mercury arc offers the most convenient way of studying these relations, as its temperature is relatively low, and in its commercial forms it is operated over a wide range of pressure, from high vacuum to more than atmospheric pressure. In the vacuum mercury arc in a glass tube, with sufficiently large condensing chamber beyond the anode, the current can be varied over a considerable range, and the outside temperature may vary between high summer and low winter temperature, but the spectrum remains the same, showing the red lines very faintly, while a carbon filament, inserted longitudinally into the arc stream, remains entirely dark (when seen through a red glass to cut off the mercury light), though entirely immersed into the arc stream, thus showing that the temperature of the arc stream is below incandescence. If, however, the condensing chamber is covered by a heat insulator, obstructing the escape of heat, and thus the condensation, the vapor pressure rises, and the red lines of the mercury spectrum become noticeable and even quite prominent, while a carbon filament immersed in the arc

stream becomes incandescent,² both showing an increase of temperature of the arc stream. At the same time, the voltage consumed by the arc stream increases. With a mercury arc in a quartz tube, at atmospheric pressure, the red lines of the spectrum are still more prominent, showing still higher temperature, and the voltage per unit length of the arc stream is higher.

If in a vacuum mercury arc in a glass tube the condensing chamber is placed beyond the anode, so that all the mercury vapor must pass through the arc stream, exposure to low winter temperature does not affect the spectrum, though much of the vapor is condensed out of the stream, showing that a small part of the vapor is sufficient for conduction. So, also, an air blast, unless very powerful, has no effect. If, however, the condensing chamber is located near the cathode, so that the surplus mercury vapor produced at the cathode does not pass through the arc stream, but is condensed before reaching the stream, then exposure to winter temperature, or even a moderate cooling blast against the arc tube, changes the spectrum. The red spectrum lines become more prominent, and the exploring carbon filament in the center of the arc stream becomes incandescent, thus showing an increase of temperature of the arc stream, though the vapor pressure has decreased. In this case, it seems, the condensation has gone so far that not sufficient mercury vapor is left in the arc stream to carry the current, and the mercury vapor apparently becomes superheated. This would then not be a normal arc any more, but an arc in superheated vapor, or a "gas arc."

By passing a high-frequency condenser discharge through a mercury vapor tube, we get an arc in which the red mercury lines are much more prominent than the green lines, and the color of the light is pinkish red. In this case, the currents are very high, but of so short duration that they cannot produce much mercury vapor, and the residual mercury vapor in the tube, in carrying the large momentary currents, is very highly superheated.

The iron arc also can be used to study these relations, though not so conveniently, due to its higher temperature. In the iron spectrum, the change with the temperature is the reverse from that of the mercury spectrum. In the iron spectrum, the intensity maximum shifts toward shorter wave lengths, with increasing temperature. Thus, while the radiation of the direct current iron arc at atmospheric pressure, with a temperature probably the boiling point of iron, gives essentially white light, a condenser discharge between cold iron terminals gives very little visible light, but a large amount of ultra-violet radiation, and is indeed the most convenient source of ultra-violet light.

TRANSIENT OR GAS ARC

Herefrom the conclusion seems to be justified that the temperature of the arc stream in the normal arc is the temperature of the boiling point of the material in the arc stream, that is, is the boiling point of the cathode material and therefore constant for all normal arcs of the same cathode material, at constant pressure of the surrounding atmosphere, but increases with increasing, and decreases with decreasing pressure of the atmosphere surrounding the arc. A rise of temperature of the arc stream above the boiling point of the cathode material would occur only by the sudden application of large current of such short duration that there is no time to form a sufficiently large saturated

²This does not mean that the arc stream is above incandescence, as the filament, longitudinal to the arc, shunts some current from the arc in this case, and thereby becomes heated.

vapor stream, or by such intense cooling of the arc stream that by condensation the amount of material in the cathode stream is reduced below the amount of saturated vapor required to carry the current.

In very long (relatively) arcs of short duration the former may be the case, especially if the arc terminals are cooled and thereby the amount of vapor reduced, and if the arcs are rapidly moved by air currents, magnetic fields, etc. In such arcs the voltage is increased beyond that required to carry the current across the gap between the electrodes in a normal arc through a bridge of saturated cathode vapor. Such arcs may in the middle of the arc stream show hardly a trace of the spectrum of the cathode material, but give essentially the spectrum of the surrounding atmosphere.

Such arcs may be called "gas arcs," as the conduction is by the gas existing in the space surrounding the arc, or "air arcs." They are not normal arcs, cannot persist for any length of time in stationary condition, but then would change to normal arcs by a cathode vapor bridge forming. Thus they must either be continuously moved through the air, by air currents, magnetic or electrostatic fields, mechanical motion of their terminals, etc., or must be of short duration, started and again interrupted.

Such gas arcs give the spectrum of the surrounding atmosphere, but show little, if any, of the spectrum of the electrode material, and that only near the electrodes. Their temperature probably depends very little on the electrode material, but very largely on the gas pressure of the surrounding atmosphere, and probably also on the nature of this atmosphere. It is doubtful whether a well defined arc stream ever forms, due to the transient nature of such arcs.

Very little is known of the electrical and other characteristics of such arcs, and experimental investigation is greatly needed, as it is these gas arcs or "transient arcs" which are the means of nitrogen fixation in the arc process.

EQUATIONS OF THE ARC

No entirely satisfactory equation has yet been derived expressing the relations between the constants of the arc, such as voltage, current, arc length, gas pressure in space surrounding the arc, etc. For the normal or stationary arc at constant gas pressure, several more or less approximate forms of equation have been proposed, but for the transient or gas arcs, which are the ones of importance in nitrification, practically no data are available, as far as I know.

The voltage consumed by a stationary or normal arc consists of two parts: a voltage consumed at the arc terminal, the terminal drop, and a voltage consumed along the arc stream, the stream voltage.

The terminal drop is independent of the current in the arc, and apparently also of the gas pressure in the space surrounding the arc, but is a function of the material of the arc terminal, and in general the lower the more volatile the material of the arc terminal. It varies from 13 volts with mercury to about 16 volts with cadmium and zinc, to 30 volts with iron and its conducting compounds, to about 36 volts with carbon. Apparently, at least with some materials such as carbon, not all the terminal drop is at the terminal surface itself, but a part of it in the vapor space immediately surrounding the terminal.

The stream voltage is approximately proportional to the arc length, it depends on the material of the arc

stream, and is in general the lower the more volatile the material of the terminal and thus of the arc stream. It increases with increasing, and decreases with decreasing gas pressure in the space surrounding the arc. It increases with decrease of current, and decreases with increase of current and as first approximation frequently has been assumed as inversely proportional to the current, and the stream voltage e_1 expressed by the equation:

$$e_1 = \frac{cl}{i} \quad (1)$$

where l is the arc length, and c a constant.

The total arc voltage then would be:

$$e = e_0 + \frac{cl}{i} \quad (2)$$

where e_0 is the terminal drop.

This equation (2) is not infrequently found in theoretical discussions of arcs. It is, however, not even approximately correct, and while the stream voltage varies with the current, and in opposite direction to it, its variation is much less than inverse proportional to the current.

From a large amount of experimental data with arcs of various lengths and currents, with various different electrode materials, I once derived the empirical equation giving the arc stream voltage as inverse proportional to the square root of the current, that is,²

$$e_1 = \frac{cl}{\sqrt{i}} \quad (3)$$

and:

$$e = e_0 + \frac{cl}{\sqrt{i}} \quad (4)$$

or rather:

$$e = e_0 + \frac{c(l + \delta)}{\sqrt{i}} \quad (5)$$

where δ is a small correction term in the arc length l , which apparently corrects for the heat and other energy losses from the end of the arc toward the electrode.

Still more extended investigations on arcs, recently undertaken, and covering a much wider range of arc length, current, etc., seem to show that equation (5) is not rigidly correct. It is, however, a far closer approximation than any other proposed arc equation in my knowledge, so that, pending further investigation, equation (5) may be considered as representative of the normal or stationary arc.

This equation (5) has the further advantage that it is not merely empirical—though derived empirically—but appears rational.

Assuming the amount of electrode vapor carried into and through the arc stream as proportional to the current, which appears reasonable, at constant gas pressure in the space surrounding the arc, the arc section then is proportional to the current. This seems to agree with experimental evidence. Consider now that the electric power consumed in the arc stream, $e_1 i$, must be dissipated from its surface, by conduction, convection and radiation. If then, as seems probable from the previous consideration, the arc temperature—with given electrode material and constant gas pressure in the surrounding space—is constant, then the energy dissipation per unit surface of arc stream is constant, that is, $e_1 i$ is proportional to the arc length l and proportional to its circumference, that is, the

²American Institute of Electrical Engineers, Transactions, 1906, p. 789; "Transformation of Electric Power Into Light."

square root of its section and thus of the current, that is:

$$e_1 i = c l \sqrt{i}$$

and herefrom immediately follows equation (3):

$$e_1 = \frac{cl}{\sqrt{i}}$$

Also, if the mass of arc vapor is proportional to the current, at constant temperature, the power required to produce the arc stream vapor is proportional to the current, $= c' i$.

Considering, as reasonable, the terminal drop e_0 of the arc as the electrical equivalent of the power required to produce the arc vapor, it is:

$$e_0 i = c' i$$

This gives:

$e_0 = \text{const.}$, that is, the terminal drop is constant, independent of current and arc length, but dependent upon the arc temperature and thus the electrode material.

The following are approximate values, for a few materials, of the constants e_0 , c , δ in the arc equation (5) for a normal arc at atmospheric pressure with the arc length l given in cm.:

	e_0 Volts	c	δ cm.
Mercury.....	13	..	....
Zinc and cadmium.....	16	..	....
Iron and magnetite.....	30	50	0.12
Titanium and its carbide.....	31	..	....
Carbon.....	36	52	0.8

Determining the Active Strength of Sulphate Cooking Liquor

Recent experiments have determined that the action of NaOH is substantially twice as drastic as that of Na₂S between the ratios of one part NaOH to one part of Na₂S and four parts NaOH to one part Na₂S when applied to sulphate cooking liquor.

The active strength of the cooking solution in terms of NaOH is expressed by the equation $S = M + (N \div 2)$, where S is the active strength of the solution, M the concentration of NaOH, and N the concentration of Na₂S.

A rapid method of determining the strength of a cooking solution is as follows: Add 10 c.c. of cooking liquor to about 50 c.c. of water in a porcelain dish. Add 10 c.c. of a saturated solution of BaCl₂. Stir vigorously, and titrate with normal hydrochloric acid to phenolphthalein end point. The number of c.c. required is directly proportional to the strength. This method is the most convenient for use in the digester house, because of its simplicity and the fact that it does not involve a consideration of the ratio of NaOH to Na₂S.—*Abstract from Forest Products Laboratory "Technical Notes."*

British Research Associations

Under the provisions laid down by the British Government for the organization of research associations in different industries and trades, thirteen associations have been formed, four are in an advanced state of development, three are under consideration and three more are proposed. Among the industries which have taken advantage of the government's co-operation in scientific and industrial research are sugar, iron, photography, portland cement, scientific instruments, rubber, glass, refractory materials, non-ferrous metals and shale oil.

Investigation of Fatigue of Metals

An investigation of fatigue phenomena in metals under repeated stress has just been started under the joint auspices of the National Research Council, Engineering Foundation, and the Engineering Experiment Station of the University of Illinois. The Engineering Foundation is providing \$15,000 a year for two years for this investigation and the Engineering Division of the National Research Council is acting in an advisory capacity, largely through its Committee on Fatigue Phenomena in Metals. The experimental work is being done in the laboratories of the Engineering Experiment Station of the University of Illinois, under the immediate direction of Prof. H. F. Moore, research professor of engineering materials and chairman of the committee above mentioned.

Plans are laid for a two years' program of tests, and apparatus and material are already arriving for the tests. It is hoped to secure a considerable amount of data on tests of various metals, including a number of tests of each metal to 100,000,000 reversals of stress. It is hoped to study the various short-time physical tests which are used for metals—such as the impact test, magnetic analysis, and short-time bending tests—to see whether any of these tests give reliable indices of the ability of the metal to resist fatigue under millions of repetitions of low stress. It is hoped that some reliable commercial test for this important property may be developed by this investigation.

A test party of four or five persons is being organized and the University of Illinois is fitting up a special laboratory with about 2500 sq.ft. of floor space for the use of this investigation.

Borax in Fertilizers

Two pounds per acre of anhydrous borax marks the limit of safety with which it may be used in fertilizer when the fertilizer is put in the row so that seeds or plants are brought into virtual contact with it. This is the opinion of the specialists of the Department of Agriculture who have been studying the matter of borax in fertilizer. As a result the Department has advised all fertilizer manufacturers and dealers in fertilizer that more than 2 lb. of borax per ton of mixed fertilizers will not be allowed unless the presence of an excess of that amount is indicated plainly on the container.

When fertilizer is broadcasted and thoroughly mixed with the soil, the Department's specialists agree, 10 lb. of borax may be contained in the fertilizer used on an acre of ground without danger to the crops. The Department describes the experience of farmers in some sections of the country as disastrous as a result of using fertilizers containing borax. It is to guard against a similar experience that the Department on Dec. 9 put into effect its drastic regulations regarding the borax content of fertilizer.

Borax is described as being "highly toxic to crop plants," and was contained in the potash derived from at least one of the new sources which were resorted to after the war had cut off foreign supplies of potash. The Department also has ascertained that nitrate of soda as imported also contained some borax. The Department is also authority for the statement that borax was "not known to have been present in appreciable quantities in the materials commercially available for fertilizer uses prior to the war."

The Technology Plan

BY WILLIAM H. WALKER

Director of the Division of Industrial Co-operation and Research,
Mass. Inst. of Technology

THE Technology Plan is an organized attempt to effect a closer co-operation between scientific and industrial effort; between the technical school and the individual industry throughout the country. Although a working relationship between educational institutions and industrial organizations has been discussed at great length, and on many occasions, little real practical progress has as yet been made.

The Technology Plan recognizes that for the present, at least, there must exist somewhere in this scheme of co-operation an element of individual and mutual responsibility on the part of those engaged in it. It recognizes that a purely philanthropic enterprise does not engender in the managers of industry that confidence which is an essential element in its success. Such men are not yet deeply interested in a strictly *pro bono publico* method of co-operative work. Hence the Technology Plan is neither eleemosynary in organization nor philanthropic in its aims and methods.

ESSENTIAL FEATURE OF THE PLAN

The essential feature of the plan is an agreement, expressed as a contract, between individual industrial organizations and the Massachusetts Institute of Technology, under which the industry pays an annual retaining fee to the Institute, in return for which the Institute assumes certain definite obligations of such a character as it is in position to meet. These obligations are in very general terms as follows:

The great demand of the industries today is for men trained to solve the many problems with which these industries are confronted. This requires, first, a knowledge of the principles of science, and second, a training in the application of this knowledge to the solution of the ever-recurring difficulties. While the first requirement is reasonably well met by the undergraduate courses of instruction at the Institute, only to a limited extent can the second be obtained in the four years allotted to undergraduate work. The student must be encouraged to spend an additional year or more in a research laboratory or advanced study.

STUDENTS TAUGHT TO SOLVE INDUSTRIAL PROBLEMS

Since the best way to learn an art is to practice it, the student is best taught to solve industrial problems by having him attempt the solution of such problems under able and experienced guidance. These problems, however, have their origin in, and owe their existence to, the industries themselves. The first point of co-operative contact, therefore, in this arrangement between industry and the Institute of Technology is that the Institute agrees to use, so far as it can, such problems as the industry will submit to it as basic material for its research work for those graduate students interested in industrial development; to give men already well grounded in science the benefit of the opportunity of working under experienced instructors upon the type of work for which they are urgently required.

STEADY STREAM OF TRAINED MEN FOR INDUSTRY

It is true also that much investigation in "pure science" can be conducted as profitably in fields of research which are closely akin to industry as in those realms of science far remote from general interest. This

does not mean that the search for knowledge for its own sake will not continue to subtend a large arc of the activities of the Institute of Technology; but rather that such search will be activated and inspired by the realization that the hard work involved and the results obtained are recognized as an essential part of a comprehensive whole. Hence the Institute agrees in its contract to maintain a steady stream of trained men constantly flowing into industry with the best preparation for scientific work which it is possible for it to give. Also, the results of research work thus obtained will swell the store of knowledge on which the scientific progress of the community as a whole depends.

TO SEEK APPROPRIATE POSITIONS FOR THE GRADUATES

But a corollary of this duty of preparing educated men is the duty to see that, as far as possible, these men take positions for which their natural ability and aptitude most nearly fit them. Further, it is desirable that, as these men develop into specialists in any particular field, their sphere of usefulness be made as wide as is practicable. Hence the Institute undertakes to maintain a record of the qualifications, experience and special knowledge of its alumni; to advise the contractor where such knowledge and experience as it seeks is available; to assist the contractor to obtain the technical help he requires, whether from its own alumni or from available engineers elsewhere. While this service has been rendered to some degree in the past, it has been a minor part of, and incidental to, other activities. It will now become a contractual obligation.

EXECUTIVES ALSO TO BE EDUCATED

Coincident with the education of scientific men, there exists the necessity of educating the executives of the industries in the great economic value of science when applied to the business of their organizations. The sporadic "Yankee genius" of the past, productive though it was, must be replaced by the method of scientific research. Genius must be provided with that most efficient tool yet produced—scientific method. While it is true that the world will ever need more knowledge, the pressing duty of industry for the present is to apply the knowledge now available. To meet this situation, the Institute provides for conferences with members of its staff, not only in its own building but also at the factories of the contractor. It is hoped that the contractor will be so imbued with the possible benefits to be derived by the application of science that he will avail himself of one of the sources of technical aid readily accessible, not only at the Institute, but among consulting engineers and industrial scientists throughout the country.

CLOSE CO-OPERATION SOUGHT

A realization of that close co-operation between the industrial interests and the educational institutions of the country which in Germany was made so effective by the domination of both by the state can, in America, be brought about only by a voluntary personal relationship between the executives of the companies and the instructing staffs of the institutions. The Technology Plan aims to make this relationship more easily possible; to provide a point of contact between the two interests; to open a channel of communication through which the manufacturer and the technical consultant can more easily meet. The contractor can obtain the value of his retainer only by utilizing the facilities thus made

available. There will therefore be present in the Technology Plan this incentive, at least to try.

The instructing staff of an educational institution is made up, at least theoretically, of men peculiarly adapted to render great public service by conducting research of a fundamental character, i.e., they are seekers after new knowledge, and yet, at the same time, are teachers and trainers of young men. It is important that these men be not withdrawn into purely industrial work by reason of the greater financial return offered by great corporations, or the acute pleasure which many red-blooded men feel in being professionally connected with great technical developments. Hence the Technology Plan provides a method by which the staff is enabled to profit by contact with men of affairs and receive the inspiration which comes from the capitalization of effort, and, at the same time, fertilize and catalyze the instructional work of the teaching staff.

HOPE IS TO INTEREST CONSULTING ENGINEERS THROUGHOUT THE COUNTRY

The Institute, therefore, agrees that if the contractor has special technical problems requiring extended consultations, investigations, tests or research work it will advise the contractor where and by whom such service can best be rendered. When one considers the splendid laboratories with which the Institute of Technology is equipped, covering as they do almost every department of applied science, and its staff, trained in the use of such laboratories, it is obvious that much of the work will be done within its own organization. But it is neither the desire nor the intention of the Technology Plan to limit the contractor to the facilities of the Institute. It is the hope of the Division of Industrial Co-operation and Research, the organization set up to handle the 190 contracts already made, that it can enlist the interest of the great body of able consulting engineers throughout the country. When, therefore, consultation, test, investigations or research work are of such nature as can be best furnished by established commercial organizations, the Institute will advise the contractor where, in its judgment, the work can best be cared for.

The Technology Plan is, therefore, a more effective means of introducing technical research to the manufacturer; of making the application of science to industrial problems popular; of creating an appreciation on the part of the leaders of industry of the value of science and the necessity of providing, not alone for its application, but for its continued growth and development.

COPY OF THE CONTRACT

Following is a copy of the contract between companies and Massachusetts Institute of Technology:

Agreement made this (blank) day of (blank) 19... between (blank), hereinafter referred to as the Company, and the Massachusetts Institute of Technology.

The Company agrees to pay to the Massachusetts Institute of Technology a retainer of (blank) dollars, in five annual installments of (blank), payable on the second day of January of each year from 1920 to 1924 inclusive.

The Massachusetts Institute of Technology agrees to make available to the Company, during the five years 1920 to 1924 inclusive, its library and files, and to arrange for conferences with its technical staff on problems pertaining to the business of the Company.

The Massachusetts Institute of Technology further agrees to maintain a record of the qualifications, experience and special knowledge of its alumni that shall

be as complete as practicable, and upon request to advise and assist the Company to obtain:

Information as to where such knowledge and experience are available.

Information regarding men for special problems.

Information regarding men for permanent employment.

The Massachusetts Institute of Technology further agrees to maintain a list of undergraduates who may wish positions upon graduation: to advise the Company upon request as to the records and qualifications of these men, and to arrange for interviews with them.

The Massachusetts Institute of Technology further agrees that in case the Company at any time during the period covered by this contract should have special technical problems requiring extended consultations, investigations, tests, or research work, it will advise the Company where this service can be best obtained. If, in the judgment of the Massachusetts Institute of Technology, this service can best be rendered by its staff or in its laboratories, a member of its staff shall undertake such service for a fee to be mutually agreed upon by the parties hereto.

It is earnestly hoped that the plan here outlined will be adopted with improvements by other educational institutions for the benefit of both education and industry.

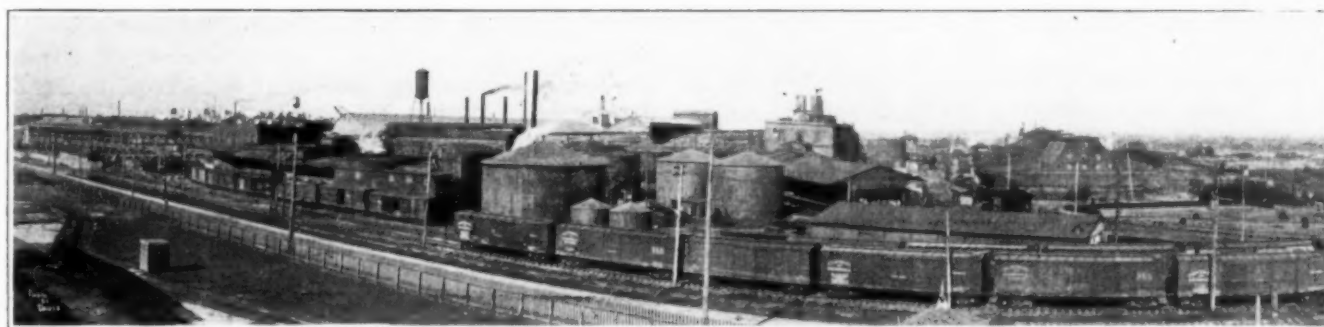
Cambridge, Mass.

Chemical Industry in Sweden

The Roberts Co. is making essences in Oerebro. A match factory has two plants for the production of phosphorus by the electric smelting method, which will satisfy the Swedish match industry, according to the *Zeitschrift für Angewandte Chemie*. Potassium nitrate is made by the double decomposition method. A government commission is looking into the manufacture of common salt from sea water. A soda works, making sodium carbonate by the Leblanc method, was undertaken during the war, and it was still uncertain in September last whether it would continue or not. There are a number of works established for the production of chromium salts, but only one of them remains and its future is dependent upon protection, according to the report published in the *Journal* of the Society of Chemical Industry. An aluminum works is under construction to reduce the metal from refractory loam by an unpublished process. Calcium carbide and calcium cyanamide are produced on a large scale, and ammonium sulphate has been made from the cyanamide in limited quantities. The country expects to be independent in future in regard to caustic soda, caustic potash and bleaching powder. Making sodium hypochlorite has been discontinued. The Birkeland-Eyde establishment at Ljunga has a small ammonia oxidation plant, and it is only here that atmospheric nitrates are made and sold. In the chlorate establishment at Trollhättan some other material than platinum is used for electrodes.

The Bohemian Glass Industry

The well-known glass-manufacturing district of Jablonec (Gablonz), in the Republic of Czechoslovakia, alone exported from Feb. 1 to Oct. 31, 1919, products valued at 17,000,000 Czechoslovak crowns, mostly to the United States, France and Italy. Previous to the war, of the 202 glass furnaces in the Austro-Hungarian empire, 162 were in the Czechoslovak domain. Of the total production for 1913, valued at 117,400,000 crowns (the normal value of the Austro-Hungarian crown was 20c. United States currency), 105,500,000 crowns represented the Czech and Slovak products.



SOUTHERN COTTON OIL CO.'S SAVANNAH WORKS

Pictorial Description of the Cotton Oil Industry

Comparative Statistics of Food Values and Efficiency of Refining Practice of Cottonseed Oil — Photographs in Sequence Illustrating the Industry From the Boll on Through the Gin, Oil Press, Refinery, Packaging and Shipping Departments

By DAVID WESSON

AS A summary to the presidential address¹ before the American Institute of Chemical Engineers, the accompanying collection of photographs, charts and tables were projected on the screen, with the intention of giving the audience a better mental picture of the cotton oil industry than could be conveyed by means of words alone.

The relative value of different foods is indicated in Fig. 1. In the first column, the percentage of fat in different food materials is shown and in the last column, the number of calories per lb. It will be noticed that the vegetable oils show 4,080 calories and are the most concentrated foods on the list.

The relative digestibility of different fats is charted in Fig. 2. This has been worked up from data furnished by the Bureau of Home Economics, based on the careful experimental work of Dr. Holmes. The upper part of the list shows the principal animal fats, the lower part gives the various vegetable fats and oils. The coefficient of digestibility is shown in figures in the first column and graphically in the second. It will be noticed that, with one exception, all the fats shown have coefficients above 90, while the vegetable oils all run between 95 and 100. It is quite evident from this table that the claim frequently made that olive oil is more digestible than cottonseed oil is not substantiated. We must bear in mind, in looking at the next three figures, that we are dealing with statistics. You must remember that Mark Twain used to say, "There are three kinds of lies, namely, lies, damned lies, and statistics"; we can say, however, on governmental authority—and we all believe what our Government tells us—that the statistics I am showing herewith are at least 90 per cent correct.

Fig. 3 shows the relative production of vegetable oils in the United States as compared with the production of animal fats. Leading the list of the vegetable oils is cottonseed oil, while at the bottom of the list is olive oil, which is hardly visible in the chart. The dotted lines

after linseed, cocoanut, peanut and soya bean oils indicate the additional amount of these oils which was imported into the country in 1918. Please pay particular attention to the difference in the production of lard compounds, or *vegetable shortenings*, as they should be called, and lard. It will be noticed that they amount to more than the hog product. Please notice also the great difference between the production of butter fat and oleomargarine. With the present high cost of living, there is no question that the latter should be produced in much greater quantities.

The growth of the cotton oil industry is shown in Fig. 4. It will be noted that in 1870 only about 4 per cent of the crop was crushed, while in 1917-18 about 90 per cent of the crop was crushed. The other curves show the millions of tons of seed and the millions of barrels of oil.

Table I shows the statistics for the cotton oil industry for the year ended July 31, 1919.

TABLE I. SEED AND PRODUCTS YEAR ENDED JULY 31, 1919

Seed crushed, 4,450,189 tons at \$70.00.....	\$311,513,230
Oil made, 1,319,926,000 lb. at \$0.17.....	230,900,000
Cake and meal, 2,158,787 tons at \$50.00.....	107,939,350
Hulls, 1,124,118 tons at \$15.00.....	16,861,770
Lint, 929,199 bales (500 lb.) at \$0.04.....	21,696,797
Total value mill products.....	\$377,397,917

Plate 1 gives a good view of a cotton field during the picking season. This view was taken some years ago when labor was far more plentiful than at present.

Fig. 5 shows the relation between the market prices of seed and summer yellow oil during the war period.

Plate 2 is an enlarged illustration of a single cotton boll.

When the cotton is picked, it is hauled to the gin. Plate 3 gives a good idea of a gin during the picking season. Loads of seed cotton are lined up awaiting their turn. It looks like a rather uneconomical system to have a whole lot of teams and men standing idle losing a number of hours' good time waiting for the cotton to go through the gin. This picture, however, was

¹History and Development of the Cottonseed Oil Industry. CHEM. & MET. ENG., vol. 21, No. 13, pp. 661-662.

taken some years ago, when labor was not so scarce as it is now.

A good idea of the interior of a gin house is given in Plate 4, showing the tiers to the right and the baling press to the left. Ventilating pipes carry off the dust and dirt from the cotton as it is being ginned. The gins consist of a lot of rapidly revolving saws which tear off the fiber from the seed. The fiber and seed are delivered separately, the fiber going into the baling press, and the seed being delivered to the mills. Plate 5 shows how seed looks in a small pile. It represents about a handful of seed.

Fig. 6 shows two sections of the cottonseed. The little black dots seen throughout the seed contain a resinous coloring matter called "gossypol," which is responsible for the dark color in the crude oil. The seeds are really small nuts about $\frac{3}{8}$ in. long and about $\frac{1}{16}$ in. in diameter. They are surrounded by a leathery shell or hull, from which grow the cotton fibers. The gin

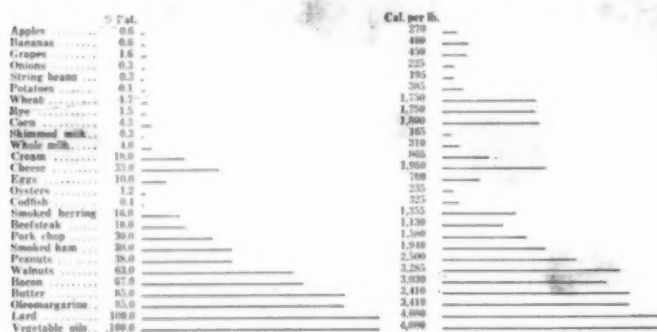


FIG. 1. RELATIVE VALUE OF DIFFERENT FOODS

always leaves a certain amount of fiber adhering to the hull. Fig. 7 shows an enlarged section of the cottonseed, portraying particularly the structure of the hull, as well as the kernel.

Table II shows analyses of cottonseed from Georgia and Texas. Please notice the big variation in the percentage of oil in the meats, that in Georgia being very much higher than that in the Texas seed, while the ammonia and protein are much higher in the Texas than in the Georgia seed.

When the seed reach the mill, they are first unloaded from the cars or wagons and delivered to the seed house. This seed house, Plate 6, is for a small mill. Ordinarily,

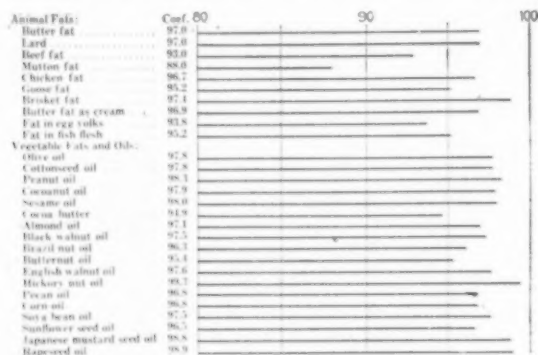


FIG. 2. RELATIVE DIGESTIBILITY OF FATS

at the bottom of the tunnel is a conveyor, into which the seed is shovelled. In a small mill, however, a conveyor is not necessary, as the seed can be put into carts and carried from the tunnel when the house is full. It is then emptied into the elevator boot at the end of the building, as shown in Plate 7.

A shaking screen which separates the seed from the bolls, stones, sticks, etc., is shown in Plate 8. The trash is collected in a bag at one end of the screen, while the clean seed is fed to a conveyor, which carries the seed to the linters, shown in the background of Plate 9. These linters are really gins which remove the lint re-

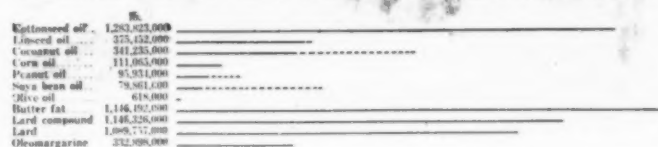


FIG. 3. PRODUCTION IN U. S. OF VEGETABLE OILS COMPARED WITH ANIMAL FATS

maining on the seed. The quality of the lint depends on the amount removed per ton of seed. During the war, the Government demanded the largest possible output, and it was the practice to remove 150 lb. of lint per ton of seed. This lint contained considerable cut hull and trash. Good practice at the present time removes 80 to 100 lb., while, if a superior quality is desired, two cuts are made: the first cut taking off 25 to 40 lb., while the second cut yields the inferior lint, as much being removed as may be desired. The linted seed next passes through the hullers, which chop the seed up fine. The mixture of hulls and meats is then passed through a series of screens and reels, which separate the hulls from the meats. Plate 10 gives a good idea of the appearance of the separating machinery in a modern mill.

Plate 11 shows a picture of a model press room, which looks as though it had been cleaned up for shutting down the mill for an indefinite period. It is altogether too clean for a mill in actual operation!

Plate 12 was taken while the mill was working. In the center is shown a French heater, where the meats are cooked, while, to the left of it, is shown the cake

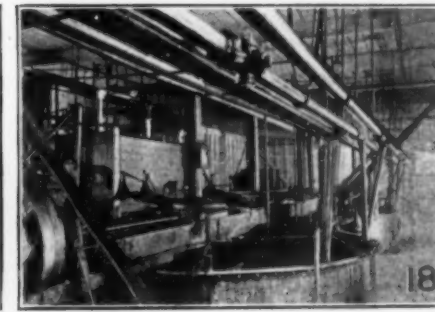
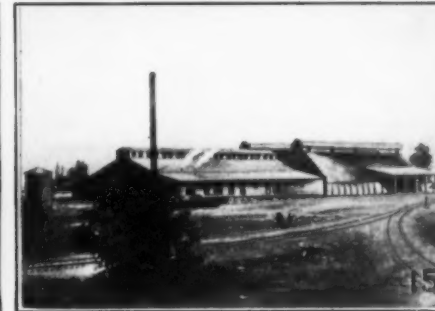
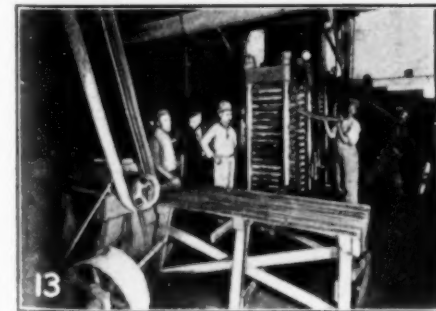
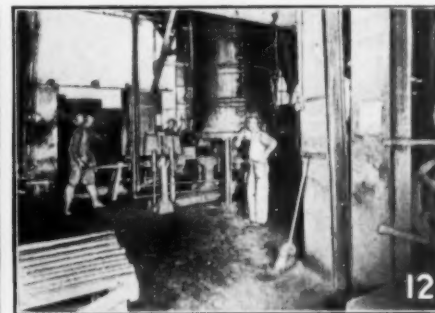
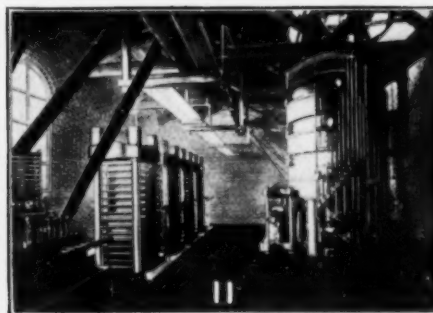
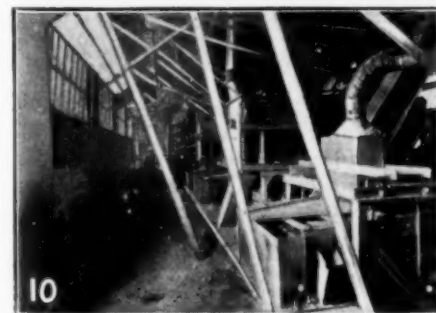
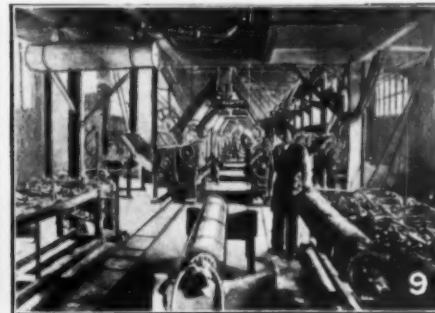
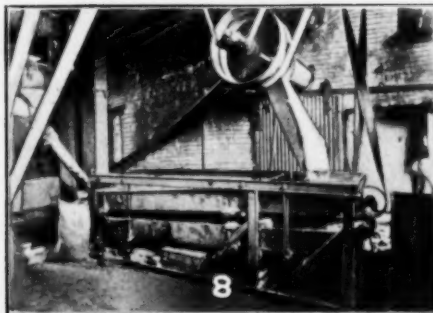
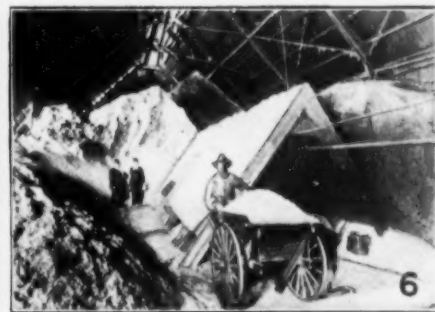
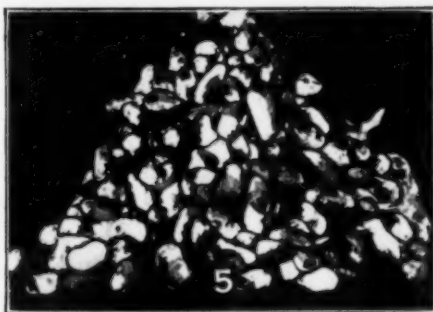
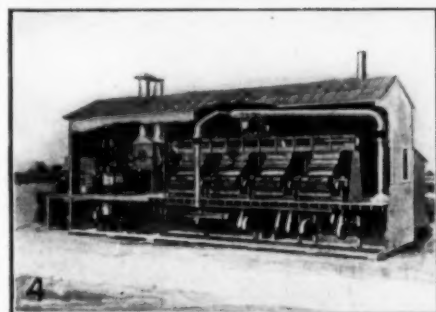
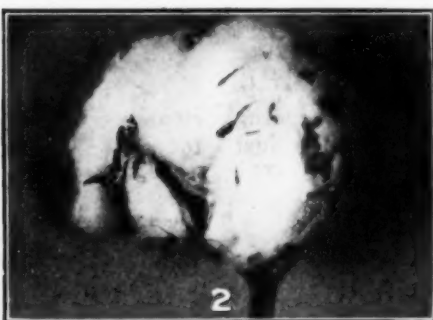
TABLE II. COTTONSEED ANALYSES

	Georgia, Per Cent	Texas, Per Cent
Hulls	45.00	47.00
Meats	55.00	53.00
Oil in meats	37.00	31.20
NH ₃ in meats	6.60	8.40
Protein in meats	36.99	43.50
Mill yields per ton of seed:	Pound	Pound
Cake	1,010.00*	1,056.00*
Oil	337.50	256.00
Linters	155.00	145.00
Hulls	375.00	515.00
Loss	123.00	100.00
* NH ₃ in cake, per cent.	7.16	8.00

former, where the cooked meats are formed up into cakes before going to the presses. The broom in the foreground is a guarantee that this picture was not fixed up for the photographer.

Another view in the same press room is given in Plate 13, showing the working of the presses. These presses make two or three turns an hour. In figuring the capacity of the mill, it is common practice to figure one ton of seed for each press plate for 24 hr.

Plate 14 shows the meal shed, where the cake, after being taken from the presses and ground, is piled up in bags ready for shipment. Plate 15 is a typical illustration of an old-time oil mill. At one end is the mill proper with the boiler and engine room, next to which is the press room, and, beyond the linters, a separating machine, while at the further end is shown the seed house, on one side, and the hull and meal houses on the other. Plate 16 is a modern mill. The large building to the right is the seed house, and the low building to



the left is the mill proper. This mill is operated mostly by electricity.

The latest thing in oil mill construction is illustrated in Plate 17. It is the New South Oil Mill at Helena, Ark. The concrete cylindrical tanks are used for storing the seed, and, according to reports, there has been no trouble so far this season from the seed heating or otherwise deteriorating.

With the reservations made regarding statistics, Fig. 8, compiled partly from the results given by D. A. Tompkins in his work on "Cotton and Cottonseed Oil," published about 1901, shows the improvement made in cottonseed milling from 1875 to 1920. In the early days of the industry, the seed was considered to be half hulls and half meats. Not much attention was paid to waste, and, besides, the gins left a great deal more fiber on the hulls than they do at present. In 1875, it will be noticed, the yield from a ton of seed was 225 lb. of oil and 675 lb. of meal. At that time, the hulls were

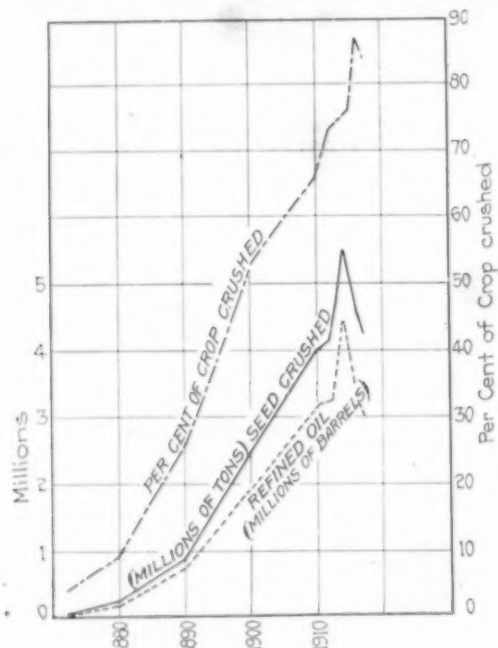


FIG. 4. GROWTH OF THE COTTON OIL INDUSTRY

burned under the boilers and not much attention paid to them. The large proportion of oil left in the meal will be noticed. In 1900 a much larger output of oil is shown, while account is made of the lint and loss, amount of hulls being the same. In 1920 we would have a quite different yield, only 60 lb. of oil being left behind in the meal, which, it will be noticed, amounts to 980 lb. altogether. It will also be noticed there is a large yield of lint, while the hulls are shrunk to 490 lb. The rest of them are something like the salesman's overcoat and the expense account; in this case, the missing hulls have disappeared in the meal.

Fig. 9 shows the results of milling a ton of seed for the year ended July 31, 1919. The crude oil, as it comes from the mill, is very dark in color, averaging about that of claret, but with a somewhat brownish cast. When it reaches the refinery, it is pumped into refining tanks shown in Plate 18, holding from 60,000 to 120,000 lb. These are provided with agitating machinery, and also large steam coils for heating the oil rapidly. Above the tanks are smaller ones for weighing or measuring in the caustic soda required for the refining. The proper amount of caustic is run into the oil, while it is

being agitated, and, after the agitation has continued for some little time, small flakes begin to form. The machinery is then slowed down and heat applied. The flakes grow larger and larger, and owing to the decreased density of the oil, on account of the heating, the flakes soon begin to flow, and when in the right condition for settling rapidly, the steam and agitation are shut off, and the tanks are allowed to settle, preferably for 24 hr. Plate 19 represents the bottom of the refining kettle, provided with a cone and heating

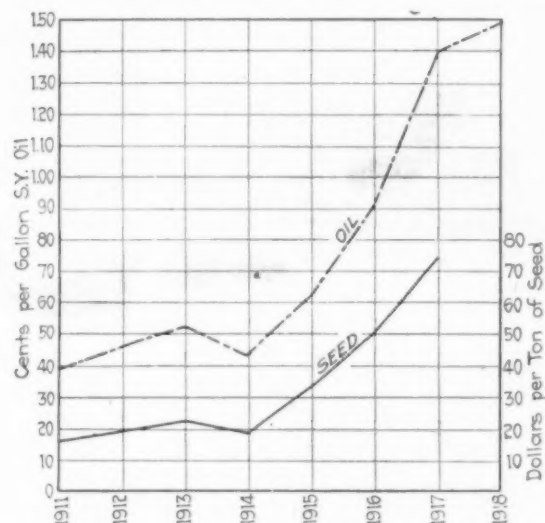


FIG. 5. MARKET VALUES OF SEED AND OIL DURING THE WAR PERIOD

jacket for melting out the soap stock after the oil has been pumped off. The light yellow oil is pumped off into large tanks, such as are shown in Plate 20, where it is allowed to settle and drop out the fine soap, which is still suspended therein.

Fig. 10 shows the relation between free fatty acids in the crude oil and refining losses. These curves were plotted from refinings made all through the season and can be considered as typical. The settled oil is transferred to kettles with heating coils and agitating machinery where a small percentage of fullers earth

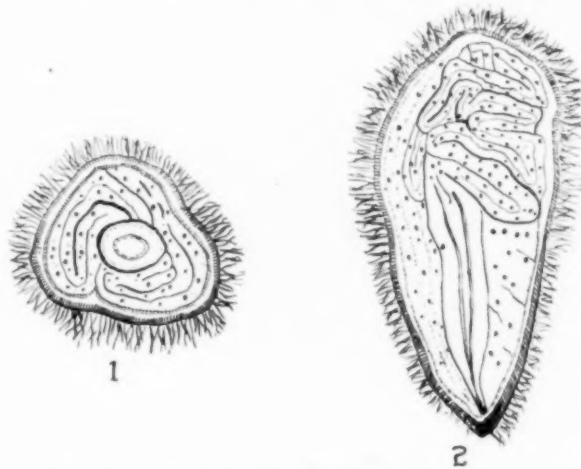
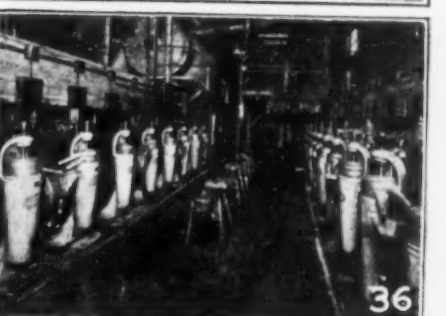
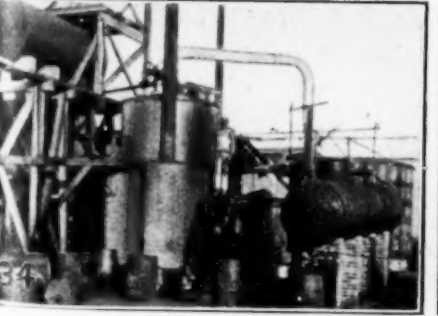
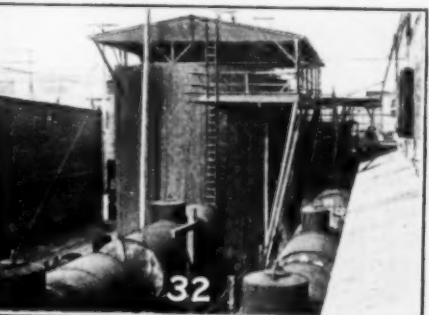
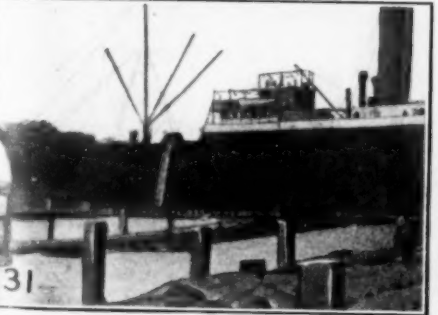
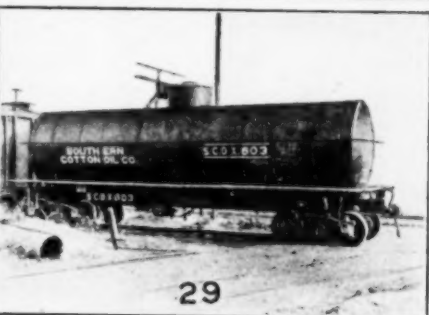
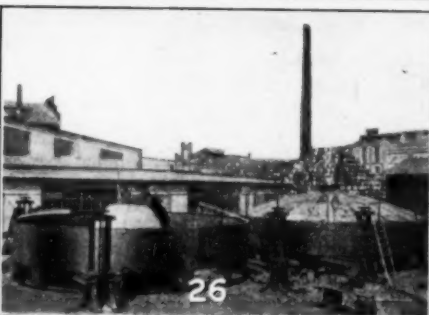
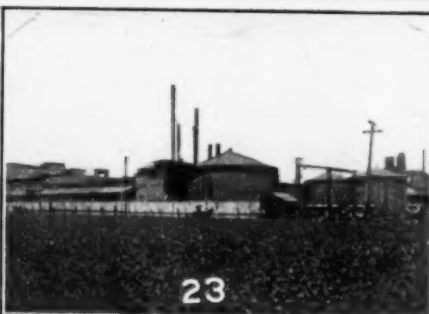
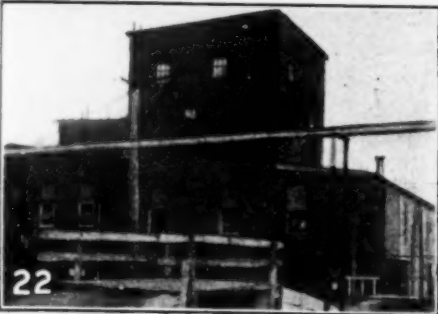
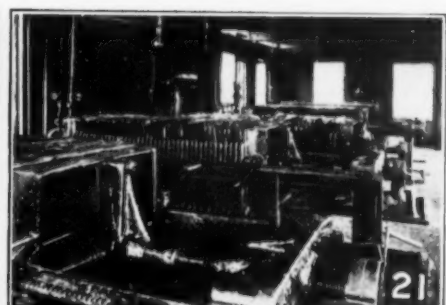
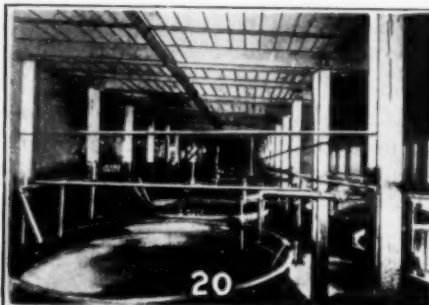


FIG. 6. TWO SECTIONS OF THE COTTONSEED

is added and well mixed with the hot oil, which is next pumped through filter presses, as shown in Plate 21. This removes the fullers earth and delivers the clear white oil, which next goes to the deodorizing kettles, after which it comes out almost water white.



The first refineries constructed in this country were mostly frame buildings, which were sufficient to protect the tanks and machinery from the weather. Plate 22 shows one of the oldest plants of the Southern Cotton Oil Co., located at Gretna, La.

Plate 23 shows the refinery of the Southern Cotton Oil Co. at Savannah, taken about 12 yr. ago. The plant has greatly expanded since that time, as shown in the large picture at the head of this article.

Another old plant, built about 1887 by the Olivers at Charlotte, is shown in Plate 24.

With such a demand for the fine quality of oil produced in America, it was necessary to put up plants in Europe. A plant which was in successful operation up to 1916 in Germany is shown on Plate 25. This plant

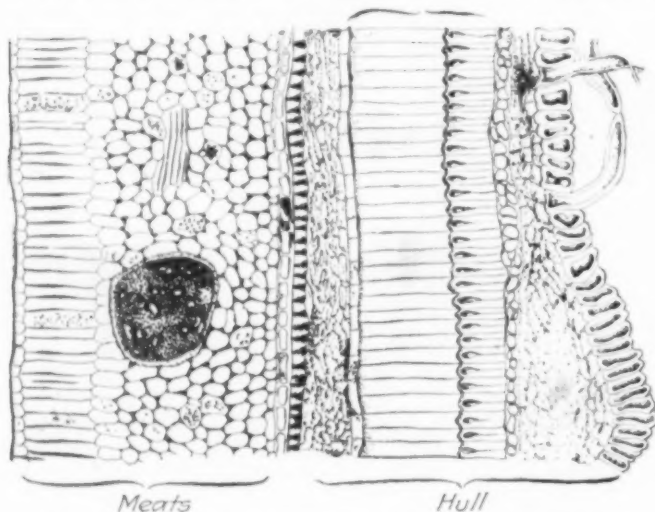


FIG. 7. ENLARGED SECTION OF THE COTTONSEED

rejoices in the euphonious name of the Wesson Gesellschaft für Deutschland mit Beschränkter Haftung. At the present time, it has somewhat beschränkt. It is of interest in this connection to show how storage tanks are constructed in Germany. The practice prior to the war was to first lay down the bottom of the tank, then set up the top ring on jacks and build the roof, as shown in Plate 26. The tank was gradually raised and new rings put on from the bottom until the bottom ring was finally put on and closed up, as shown in Plate 27. This saved the expense of scaffolding, and, at the same time, kept the men on the ground.

Transportation is an important feature in all industries. It is quite common around oil mills, even today, to see ox teams, as shown in Plate 28. On the face of it, these teams appear rather slow and possibly expensive transportation, but when it is considered that old scrawny steers can be bought very cheap and fattened on meal and hulls at the same time they are making themselves useful as beasts of burden, it is not such a bad proposition as appears on its face. In the early days of the industry, the crude oil was shipped from the mills to refineries in the North in all kinds of cooperage. The speaker has frequently seen lighter loads playing around New York harbor which looked like a package of firecrackers. The barrels, on examination, are found to have been used for kerosene, naphtha, lubricating oils, varnish, whiskey, and what not. In this connection, I remember at the old plant of the N. K. Fairbank Co., 14th St., New York, the night man emptied a lot of oil barrels into a tank to be refined the next morning. The oil in the tank had a

flavor never before noticed in crude cottonseed oil. It was found that by mistake a barrel of whiskey had been emptied along with the oil, and there was great lamentation on the part of the steamship company, as well as the men who committed this gross carelessness. Nowadays, crude oil is almost entirely handled in large tank cars, holding as much as 250 bbl. of 400 lb. each. Such a car is shown in Plate 29.

Plate 30 shows the tracks at a modern refinery filled with tank cars ready for unloading. For European shipment, the oil has to be shipped in carefully prepared barrels. Plate 31 shows a steamer being loaded for Europe at our New Orleans refinery.

In a talk on the cotton oil industry, sight must not be lost of the soap stock. The early refineries used to boil this material up with caustic soda and convert it into a soft, yellow soap, which was used more or less by woolen mills. This soap was also boiled down on strong brine until it carried about 30 per cent of water, which made it suitable for export to England, where large quantities were used. About 1886, it was found that by mixing the soap with soda ash, it could be made into very useful washing powder, which has since been advertised extensively by means of the Gold Dust Twins. In the plant of the Southern Cotton Oil Co. at Savannah, the speaker once needed some large soap kettles in a hurry, so he removed the covers from some storage tanks, lagged outside with wood, built a roof over the tops of the tanks, and these were used for some years quite successfully. As these tanks are somewhat of a novelty in the way of soap kettles a picture is shown in Plate 32.

Plates 33 and 34 show the first plant put up in Savannah for the distillation of the black grease made by decomposing the cottonseed soap stock with sulphuric acid. It was more or less of a temporary affair, which met with a sad accident and burned down a couple of years after it was put up.

On account of more or less destructive distillation

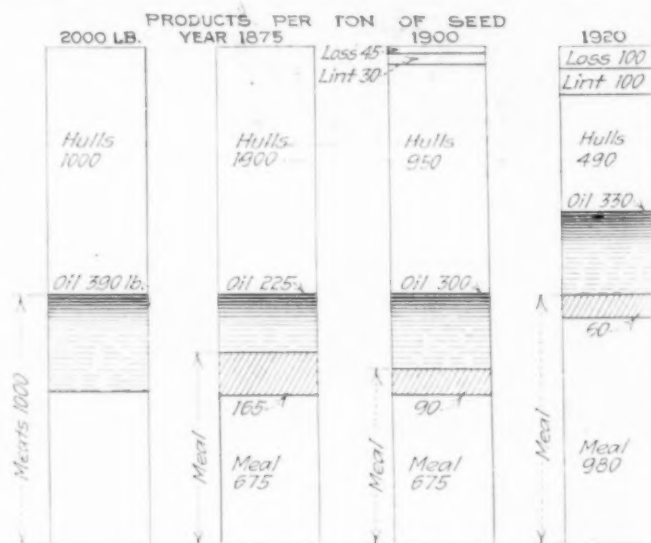
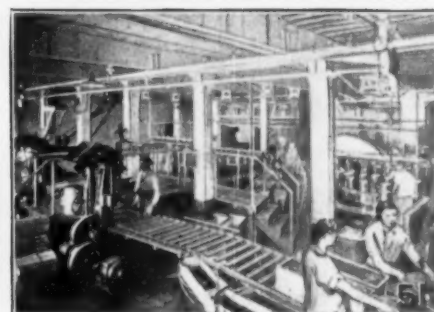
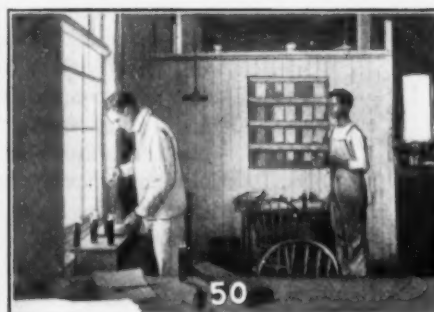
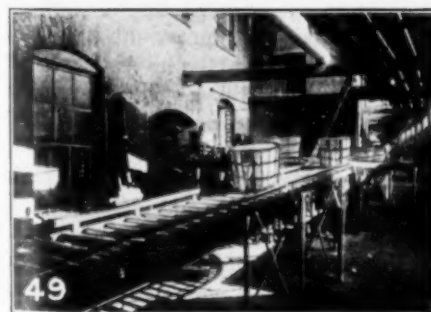
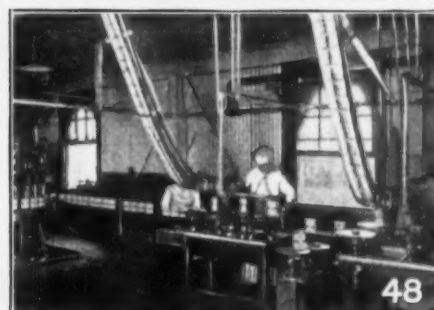
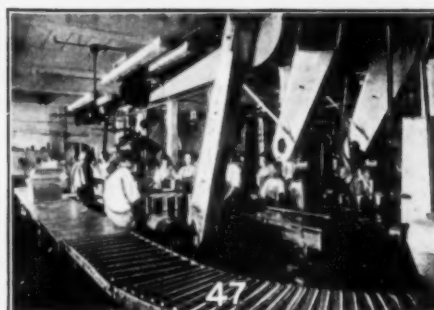
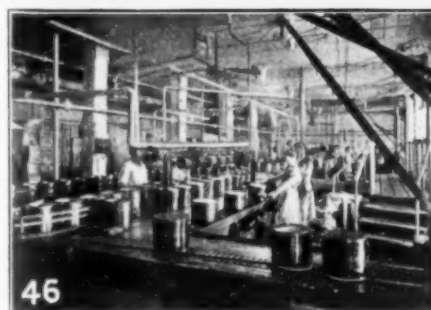
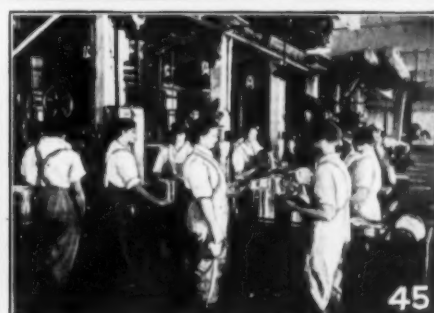
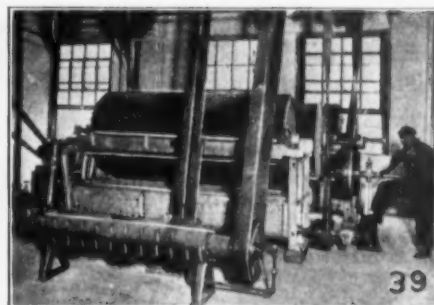
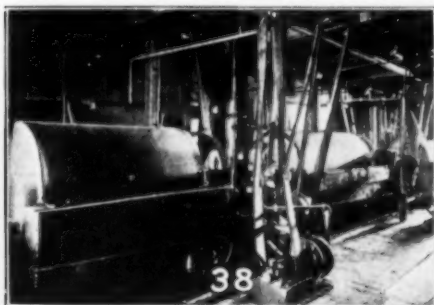
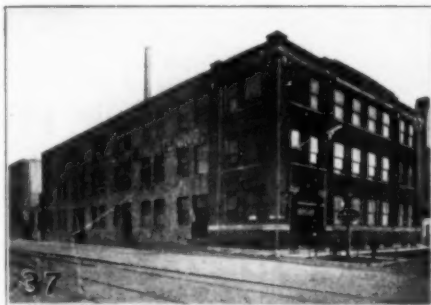


FIG. 8. IMPROVEMENT IN COTTONSEED MILLING, 1875-1920

taking place, owing to the impurities of the black grease, the vapors in the stills were very destructive to copper. Plate 35 shows a copper connection between two of the condensers after it collapsed one day and scared the operators nearly to death.

The modern way of handling soap stock is by means of the Sharples super-centrifuges, which are shown in



battery in Plate 36. These recover between 60 and 70 per cent of the entrained oil from the soap stock and reduce the refining loss about 1 per cent. Plate 37 shows one of our latest vegetable shortening plants, located in Chicago. In the manufacturing of vegetable shortening, the oil and hard fat, which, in these days, is almost exclusively hydrogenized cottonseed oil, are mixed in large tanks and then passed over revolving cylinders through which brine from an ice machine is circulated. Plates 38 and 39 show these cylinders in operation. The lard is fed into a trough in which the cylinders set and is chilled on the surface of the cylinder as it revolves. Knives scrape the chilled lard from the surface of the cylinder, in such a way that it continually drops through into a trough in which there is a rapidly revolving shaft covered with blades which break up all the lumps and beat a certain amount of air into the lard. Pumps take the shortening, which is of a creamy consistency, from this trough and pump it directly into the packages.

Plate 40 shows the filling room in the Savannah plant, taken about 15 yr. ago, and Plate 41 shows another view in the packing room. Please notice the large amount of labor present, and also notice that it consists almost entirely of men. Another view of the same work at that time is given in Plate 42, and Plate 43 shows the filling of tubs and large packages. Plate 44 shows the way the product was loaded into cars about 12 or 15 yr. ago.

During the last few years, automatic machinery has been installed and in the words of the song, we "let the women do the work." In Plate 45 girls are shown

to the carrier and properly pile them in the cars where they are delivered.

In the old days, help around the refineries consisted largely of negroes. Plate 53 shows the gang that used to work in the Memphis refinery of our company.

Plate 52 shows one of the early chemists already

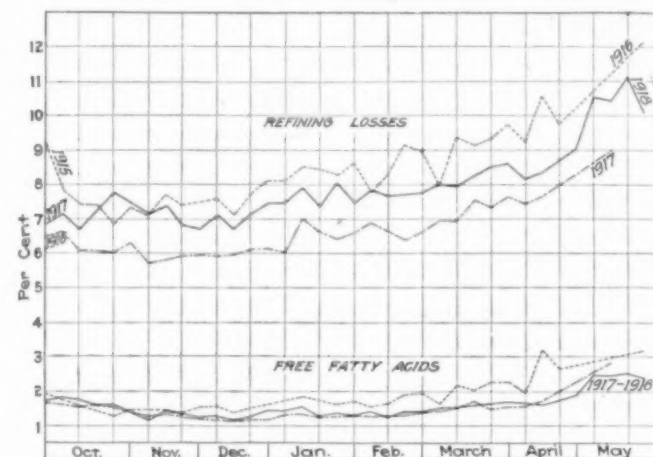


FIG. 10. RELATION BETWEEN FREE FATTY ACIDS IN CRUDE OIL AND REFINING LOSSES

mentioned, and the kind of an outfit used by him for testing his crude oil to see if it was refined properly. This gentleman now occupies an exalted position with one of the large companies.

Plate 50 is another laboratory view, and shows a young chemist grading oil samples for color. In the early days of a certain refinery I know of there was a colored assistant for nearly every white man in the refinery.

A great deal has been said of the wonderful virtues of highly refined cottonseed oil. Eighteen years ago I made some experiments with a certain well-known brand of oil, which has been extensively advertised, believing that the butter fat of cream could be replaced by the oil and successfully worked into ice cream. An experiment tried in my laboratory seemed to prove the theory to be correct, as is shown in Plate 54.

Government Picric Acid Plant for Sale

The ordnance branch of the War Department is offering for sale the buildings, land and equipment comprising the picric acid plant near Little Rock, Ark., which was constructed for war purposes. The buildings which are being offered for purchase include a sulphuric acid plant, a sulphuric concentrator plant, a nitric acid plant, a phenol storage building and a nitrate building, in addition to more than 65 shops, dwellings and small structures.

Not included in the proposed sale, however, are the water supply and gas systems and a power house, which were recently sold to the Arkansas Light & Power Co., providing that company would furnish future purchasers of the remaining buildings and plants with power, gas and water accommodations at prevailing rates.

The plant is readily convertible, officials of the War Department point out, into an oil refinery or fertilizer manufacturing establishment. With the increasing realization on the part of Arkansas and Louisiana cotton and rice growers of the necessity of fertilizer, attention has been called to the particularly favorable location of the plant for the manufacture and distribution of fertilizer.

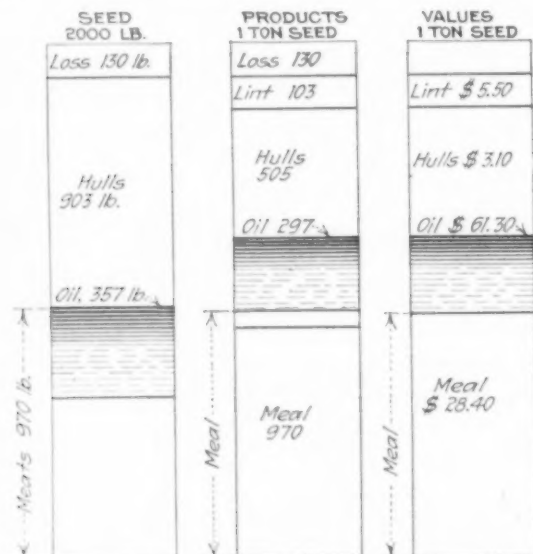


FIG. 9. RESULTS OF MILLING A TON OF SEED

filling large size cans. These are handled altogether by automatic machinery, as is shown in Plate 46, which is a picture of the same filling room shown on a preceding plate. Notice the few hands present and the neat orderly character of the work.

Other views of the same room are given in Plates 47 and 51 and show one of the automatic carriers for handling filled tins. Plate 48 shows the arrangement for filling and automatically soldering oil in cans.

An automatic carrier for loading tubs into cars is shown in Plate 49. This is on the shipping platform and will serve cars along a platform 200 or 300 ft. in length, the only labor needed being to put the tubs on

Recent Chemical and Metallurgical Patents

Complete specifications of any United States patents may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

Hydrometallurgical Process for Copper Ores.—In the extraction of copper from its ores by leaching with dilute sulphuric acid the cost of the acid is a major item of expense and, where the ores contain excessive amounts of lime or other acid-consuming constituents, is often prohibitive. The solution of copper is also accompanied by a solution of iron, which is usually associated with oxidized copper ores, and if the copper is to be recovered from the solution by electrolysis, the pressure of excessive amounts of iron results in low current efficiency necessitating the removal of the iron from solution. The usual method is to withdraw a portion of the solution from the circuit and precipitate the copper upon scrap or sponge iron, the copper-free liquor being wasted; this causes a further loss of sulphuric acid and added expense for the iron.

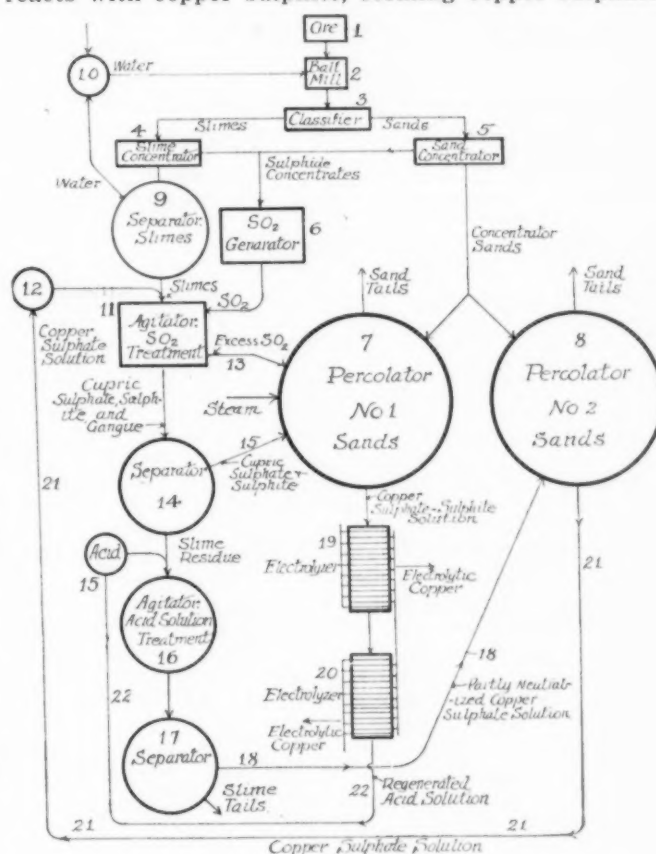
WILLIAM E. GREENAWALT uses sulphurous and sulphuric acids as a solvent for copper; the solution is electrolyzed and by effectively applying the sulphur dioxide liberated in the electrodeposition as a depolarizer an economical current efficiency is obtained. A further result of electrolysis is the production of sulphuric acid from the copper sulphite, making the process self-sustaining. It is possible to leach a portion of the copper from an ore by means of sulphurous acid, but the remaining copper is soluble with difficulty by this reagent. Sulphuric acid, being a more effective solvent, will dissolve a larger percentage of the copper than sulphurous acid. It is economical, therefore, to first treat the ore with dilute sulphurous acid, to separate this solution from the ore and then retreat with a solution of sulphuric acid. By this procedure a large proportion of the acid-consuming constituents of the ore are neutralized by a relatively cheap solvent and the maximum efficiency of the more expensive sulphuric acid obtained.

In case an ore containing both oxidized and sulphide copper is to be treated, the sulphide copper is removed by concentration and the concentrate roasted, supplying sulphur dioxide and rendering the copper soluble in the leaching solutions.

The application of the process is indicated in the accompanying flow sheet. The ore from bin 1 is mixed with water and ground to from 8 to 20 mesh in the ball mill 2, the pulp flows to a classifier 3 and is separated into sand and slime. The sulphide copper is separated from the slimes in the concentrator 4, and from the sand in the concentrator 5, the concentrates being delivered to a roaster 6, designated in the sketch as "SO₂ generator." The concentrator sands are delivered to the percolators 7 and 8. In the flow sheet No. 1 percolator contains fresh sands and No. 2 a charge treated with sulphurous acid or sulphur dioxide only. The slime tailings from concentrator 4 flow to the separator 9 and are dewatered, the water returning to tank 10 and then being fed to the ball mill as desired. The dewatered slimes pass to the agitator 11 for treatment with the SO₂ gases from the roaster 6, together with neutral copper sulphate solution from the treatment of a previous charge in perco-

lator No. 2. A fairly strong gas is preferred for this operation and the excess of sulphur dioxide is introduced into the bottom of percolator No. 1 and is consumed in acting upon the copper and other constituents of the sands that are affected by the gas or its solution in water. The mixture of gangue, cupric sulphate and sulphite, ferrous sulphate and sulphurous acid is separated from the residue in a Dorr thickener 14 and the solution fed to percolator No. 1. The slime residue, now containing the more difficult extractable copper, passes to the acid Dorr agitator 16.

The copper solution from the separator 14 in passing through the sands in the percolator No. 1 issues thoroughly clarified and practically neutral and contains the copper as sulphate and sulphite, ferrous iron and some sulphurous acid. The solution flows to the electrolytic cells, copper being deposited on the cathodes and an equivalent amount of sulphuric acid being liberated at the anodes. This liberated acid reacts with copper sulphite, forming copper sulphate



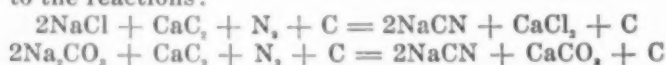
FLOW SHEET OF PROCESS

and liberating sulphur dioxide, which acts as a depolarizer and also reduces any ferric salts; these in turn act as a depolarizer. The deleterious effect of ferric salts is thus obviated to a large extent.

The solution from the electrolytic cells 19 and 20, which is impoverished in copper and enriched in acid, flows into the acid solution reservoir 15 and thence into the acid agitator 16 and there extracts the copper remaining in the slimes. The pulp flows to a Dorr thickener 17, the slime tails go to waste and the solution to No. 2 percolator, where the remaining acid is consumed in acting on the copper in the sands. The solution from the percolator is now nearly neutral and is delivered to the storage tank 12 and used in treating a fresh batch of slimes in agitator 11 as desired. (1,328,666; Jan. 20, 1920.)

Sodium Fluoride.—To a suspension of sodium fluosilicate in water, a solution of soda ash is added at such a rate that the solution reacts continuously either acid or neutral. The mixture is kept at a temperature of about 205 deg. F. and is agitated constantly until all of the soda ash solution has been added. When the agitation is stopped, the sodium fluoride crystals, being heavier than the silica particles, settle first and may be separated by repeated fractional settling. The crystals contain 98.26 per cent sodium fluoride. (1,324,030; FREDERIC C. BOWMAN, of New York, assignor to General Chemical Co.; Dec. 9, 1919.)

Alkali-Metal Cyanides From Calcium Carbide.—When calcium carbide is heated with sodium (or potassium) chloride or carbonate until the latter fuses and a stream of nitrogen is forced through the mass, alkali-metal cyanide is formed, presumably according to the reactions:



The presence of free carbon in the mass is beneficial if not essential to the formation of the cyanide on a commercial scale. (1,324,119; CHARLES B. JACOBS, of Bloomfield, N. J., assignor by mesne assignments to Air Reduction Co.; Dec. 9, 1919.)

Book Reviews

HENDRICKS' COMMERCIAL REGISTER OF THE UNITED STATES FOR BUYERS AND SELLERS, twenty-eighth annual edition, 1919-1920. 2703 pp. Price, \$12.50. New York: S. E. Hendricks Co., Inc.

The constant expansion of the chemical industry is bringing it into closer contact with other manufacturing industries and, as a result, the chemist is looking outside of his own field for new raw materials and new markets. To him, the usefulness of a trade directory such as Hendricks', which covers the entire manufacturing field from raw material to finished product, is self-evident. In spite of the wide range of materials considered, the treatment of each industry is very thorough and the chemist will find that the products of and equipment for the chemical and allied industries have received careful attention. The directory is of particular interest to the sales and purchasing departments. For the former it contains complete lists of all prospective customers and for the latter it shows at a glance the producers of any material required.

An improvement in the new edition is the method of exterior indexing by coloring the front edge red, white and blue to indicate the different main sections of the book. The first section (blue) of 162 pages is the "Index to Trades," in which every product listed in the book is indexed and cross indexed for ready reference. The following section (red) is the main classified trades list and contains 1,813 pages covering over 18,000 different products. In the third section (white), 216 pages are devoted to trade names, arranged alphabetically and followed by the name and address of the manufacturer. An alphabetical list of all the companies referred to in the book, together with their addresses and main lines of business, completes the volume.

ALAN G. WICKOFF.

"THE JOURNAL OF THE INSTITUTE OF METALS." Vol. XXII. 428 pp. and 31 plates. Edited by G. Shaw Scott, M. Sc. (1919: The Institute of Metals, 36 Victoria St., London, S. W., 1, England. Price 31/6 net.)

This volume contains the technical papers presented before the fall meeting held in Sheffield in September, 1919; the 1919 May Lecture held in London—"Radio-Activity," by Prof. Frederick Soddy; and abstracts of metallurgical

literature. This section containing abstracts is by no means the least valuable feature in the eyes of anyone interested in non-ferrous metals; an idea of their excellence may be had if the names of the men who prepared them are listed: The editor, and Messrs. Archbutt, Desch, Hanson, Johnson, Mazzucchelli.

Various contributions of more than usual interest should be cited. Dr. Desch's "Second Report to the Beilby Prize Committee of the Institute of Metals on the Solidification of Metals From the Liquid State" has been reprinted almost entirely in *CHEMICAL & METALLURGICAL ENGINEERING*, vol. 21, p. 773 (Dec. 24, 1919) under the caption "Effect of Surface Tension on Crystalline Form." Dr. Jeffries' "Note on the Micro-Mechanism of the Aging of Duralumin" is also given in the same volume, p. 553. Messrs. Stead and Spencer's beautiful micrographs of curved crystalline plates contained in their paper "The Ternary Alloys of Tin-Antimony-Arsenic" were utilized in Mr. Seyt's interesting letter on "Contributions by Metallography to L'Art Nouveau" (*CHEMICAL & METALLURGICAL ENGINEERING*, vol. 21, p. 656).

Other papers are worthy of careful attention by men in special branches of metalworking. Such are "Season Cracking," by W. H. Hatfield and G. L. Thirkell; "Properties and Manufacture of Sterling Silver," by E. A. Smith and Harold Turner; "Britannia-Metal," by F. C. Thompson and F. Orme; "A Typical Bearing Metal," by Miss H. E. Fry and W. Rosenhain; "Molding Sands," by P. G. H. Boswell, and "The Early History of Electro-Silver Plating," by R. E. Leader. All of these papers excited lively discussions in which additional interesting sidelights were disclosed, while two of them are appended by exhaustive bibliographies of the available literature.

E. E. THUM.

SEWAGE DISPOSAL. By Leonard Kinnicutt, C. E. A. Winslow and R. Winthrop Pratt. 548 pages, illustrated. New York, 1919. John Wiley and Sons, Inc.

The new second edition of this book will be of considerable interest to the large number of engineers familiar with the first edition, and of great value to everyone interested in the general problem of sewage treatment. As a very readable history of the art of treating the collected wastes of civilization brought up to date by the addition of several chapters and supplementary paragraphs, it is a concise, clear presentation of the general problems involved and the various methods of attacking them, with descriptions and tabulations of the results obtained. It should be classed as an intermediate book, as it assumes an elementary knowledge of chemistry and bacteriology, but describes the various processes and accepted theories in a manner that will be clearly understood by the average reader. The details of design are passed over in a general manner to make way for the full discussion of the broader problems of sewage purification within the scope of one volume.

The chapters on Screening, on Sludge Disposal and on Chemical Precipitation have been reconstructed and enlarged. A discussion of the Boston and New Haven studies of the Miles Acid Process has been inserted. The newer processes of two-story tank operation and activated sludge treatment setting forth experience obtained at Cleveland, Chicago and Milwaukee have been discussed in new chapters; and two chapters have been added, one dealing with excretal disposal in the absence of sewerage, and the other dealing with general principles controlling the selection of type and required refinement of operation of sewage treatment plants. It is to be regretted that the valuable tables giving results of operation copied from the first edition were not brought up to date to indicate the effect of time and experience upon the efficiencies of some of the older plants.

The general air of the volume is optimistic concerning the ultimate solution of the sewage problem, and it is pointed out that whereas each newly-discovered process of treatment has been hailed as the end of the search and then has failed to live up to expectations, the knowledge of the subject is constantly increasing, so that the best method of treatment for a given condition may now be selected from a greatly augmented number of processes and special designs.

MALCOLM PIRNIE.

Personal

WALTER M. BERRY has been appointed gas engineer for the Bureau of Standards, Washington, D. C., succeeding R. S. McBRIDE, who is now in the Washington, D. C., office of the McGraw-Hill Co.

AUGUSTINE DAVIS has resigned as president of the Davis-Bournonville Co. No successor to the presidency has been elected, and there has been no change in other officers of the company.

BARON G. DE GEER, superintendent of the open-hearth and electric-steel furnaces at Domnarfvet, Sweden, is visiting the steel plants in the United States.

A. H. FAY, mining engineer in charge of accident and certain other statistics for the U. S. Bureau of Mines since the foundation of the Bureau, has resigned to enter private employment.

FREDERIC J. LE MAISTRE has severed his connection with E. I. du Pont de Nemours & Co., and has formed a partnership with Wallace P. Cohoe, of 111 Broadway, New York, under the firm name of Wallace P. Cohoe & Frederic J. Le Maistre, associated consulting chemists and engineers, New York and Philadelphia. The Philadelphia office will be at 810 Bellevue Court Building.

BARON J. MANNERHEIM of Sweden is in the United States as a special representative of the Swedish Pulp Association. He is the guest of Dr. James E. Campbell, president of the Dexter Sulphite Pulp & Paper Co., who is conducting him through the local paper and pulp mills.

R. H. MINTON, recently elected president of the American Ceramic Society, will leave for Europe this month for an extended investigation of conditions in ceramics abroad.

FOREST RUTHERFORD, consulting metallurgist, 120 Broadway, New York City, has returned to New York after making an extended trip through the Southwest.

CASPER SMITH, president of the Smith Chemical & Color Co., New York, has recently returned from a two months' business trip through the United States, extending from coast to coast.

H. L. SULMAN has been awarded the gold medal of the Institution of Mining and Metallurgy, London.

WILLIAM A. WALDIE, for the past few years chief chemist at the Cleveland plant of the Glidden Co., has resigned to associate himself with the Ohio Varnish Co. in the capacity of director of research.

Obituary

JOSEPH M. FLANNERY, president of the Standard Chemical Co., Pittsburgh, Pa., died at his home, Feb. 18. To Mr. Flannery is due the introduction of vanadium in the steel industry, marking an epoch in the advance of steel making.

J. K. PROCTOR, founder and for many years president of the Philadelphia Textile Machinery Co., Philadelphia, Pa., and originator and inventor of the "Proctor" driers, died Feb. 11, of pneumonia.

CHARLES A. WEEKS, the inventor of the Weeks rotating furnace for non-ferrous metals, died on Saturday, Feb. 21. His death was a surprise and shock to friends and associates alike. Previous to the invention of the electric rotating furnace, Mr. Weeks built a number of rotating gas and oil furnaces from which he obtained his original basic ideas covering the subject. He invested his own capital for the manufacture of a furnace of approximately two tons capacity which was installed and operated at the General Electric Co., Schenectady, nearly eight years ago. The reason that the furnace was not immediately placed on the market was because the non-ferrous field had developed only to a small extent—crucibles were cheap and a systematic investigation of losses in melting had not shown up the tremendous losses through volatilization.

Current Market Reports

The Non-Ferrous Metal Market

New York, March 8.—There has been little change since last week's report.

	Cents per Lb.
Copper, electrolytic.....	19.00
Aluminum, 98 to 99 per cent.....	33.00
Antimony, wholesale lots.....	12.00
Nickel, ordinary.....	43.00
Nickel, electrolytic.....	45.00
Tin, Straits, spot.....	64.50
Lead, New York, spot.....	9.00
Lead, E. St. Louis, spot.....	8.37½
Zinc, spot, New York.....	9.30
Zinc, spot, E. St. Louis.....	9.00

OTHER METALS

Silver.....	oz.	\$1.29½
Cadmium.....	lb.	1.50
Cobalt.....	lb.	1.50
Platinum.....	oz.	150.00
Iridium.....	oz.	250.00
Palladium.....	oz.	150.00
Mercury.....	75 lb.	90¢@92

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled.....	29.50
Copper sheets, cold rolled (over 14 oz.).....	31.50
Copper bottoms.....	38.00
Copper rods.....	27.50
High brass wire and sheets.....	26.50
High brass rods.....	23.75
Low brass wire and sheets.....	28.50
Low brass rods.....	29.50
Brazed brass tubing.....	38.25
Brazed bronze tubing.....	43.00
Seamless copper tubing.....	33.50
Seamless bronze tubing.....	34.50
Seamless brass tubing.....	32.00

SCRAP METALS

	Cents per Lb.
Aluminum, cast scrap.....	23½@24½
Aluminum, sheet scrap.....	22½@23½
Aluminum clippings.....	25½@27
Copper, heavy machinery comp.....	14½@14½
Copper, heavy and wire.....	13½@14
Copper, light and bottoms.....	12½@12½
Copper, heavy cut and crucible.....	16½@17
Brass, heavy.....	11½@12
Brass, casting.....	10½@10½
Brass, light.....	9@9½
No. 1 clean brass turnings.....	9½@10
No. 1 comp. turnings.....	12@12½
Lead, tea.....	5½@5½
Lead, heavy.....	6@6½
Zinc, scrap.....	6@6½

The Iron and Steel Market

Pittsburgh, Pa., March 5, 1920.

Despite the many claims of production of pig iron and steel and the finishing of steel being greatly hampered by transportation conditions, operations continue to grow, although with occasional backsets. The attitude of the iron and steel industry in this matter is in somewhat striking contrast to the sanguine temperament it usually exhibited before the war. Pig-iron production is now at about 90 per cent of capacity, figured against the conservative estimate of 43,000,000 gross tons per annum, or 86 per cent, figured against the more liberal and probably more accurate estimate of 45,000,000 tons capacity.

In some quarters it is being asserted that steel production is not in keeping with pig-iron production, although the ingot report for January showed an 83 per cent production and that pig iron is accumulating at steel works. This, if true, would be extremely awkward for the pig-iron market, which has had the spectacular advance to above \$40, and not simply for prompt delivery, but for deliveries extending over the second half of the year. It is decidedly doubtful whether steel products could be sold at this time for delivery throughout the second half of the year at prices that would justify the payment of \$40 for the pig iron from which to make the steel.

Inasmuch as iron and steel markets have for years been made partly by psychological influences and not wholly by the actual physical conditions as to supplies and requirements, it is of value to consider the producing trade's mental attitude at this time, as suggested by the above illustrations. In last week's report one aspect of buyers' psychology was referred to—the growing revolt against price dictation by the automobile industry, which does not consume any such percentages of the steel output as to justify

its having much voice in setting prices for the whole market. In the past week the automobile trade has given further exhibitions of its disregard for the cost of materials and its anxiety to secure heavier deliveries. It has paid 12@14c. a lb. for automobile body sheets, leading some sheet mills to buy limited tonnages of sheet bars at \$90. A week ago the high point was \$80, and the purchases at fancy prices had been made chiefly by middle interests or consumers, for the purpose of making conversion contracts. There are still fairly large deliveries of sheet bars at the March 21 price of \$42. The 10-yr. pre-war average was between \$25 and \$26.

Several large producers have been covering their regular customers for second quarter deliveries at 2.90@3c. for bars, 3@3.10c. for shapes and 3.25@3.50c. for plates, but they are quite indisposed to advertise the fact, some because they have no room for new customers and some, perhaps, because they wish to charge higher prices to buyers not their regular customers.

MARKET LACKS REAL TEST

When steel is so scarce and the market exhibits such signs, superficially at least, of there being such buying power, it is altogether without precedent that at the beginning of March producers should be selling only to second quarter. The market lacks the real test, of whether buyers would take hold for third quarter or second half. The Steel Corporation, of course, is sold much farther ahead, but its prices are altogether different.

Export bookings are now very light, the exchange situation and perhaps some other factors preventing there being as large demand in that quarter as formerly. For small lots for prompt shipment, however, export houses are seeking largely in vain.

Conservative estimates are that in the present freight-carrying movement the railroads will take, with a few orders already placed, a total of 40,000 cars. More sanguine estimates place the total at 100,000 cars, but even the larger figure would be less than one-half the number bought in some previous years. Not much more rail buying is expected for this year. As to general construction work, the railroads seem to have little planned. Altogether, the volume of steel likely to be taken by railroads during the remainder of this year is very much smaller than the estimates apparently made by other steel buyers who have been fearful that they would not be able to secure the steel they needed.

In view of the large and increasing production, the growing conservatism of buyers, the smaller export prospects, the quantity of railroad steel to be taken and the disinclination of many investors to engage in construction projects at this time, it seems quite possible that the steel market will assume a new alignment within a few months. There is little if any reason to doubt that there will be a full demand for steel at moderate prices, but some of the prices now going are distinctly immoderate.

PIG IRON

The market is extremely quiet. Bessemer and foundry remain at \$42, valley, and there is no particular reason to expect a recession in the near future, but basic, after declining from \$43 to \$41.50, as recounted a week ago, is by no means strong at the lower figure.

STEEL

As noted above, sheet bars have sold at \$10 higher, \$90, this being in small lots. Producers having regular sheet mill customers have entirely abandoned the idea of covering their customers at \$60, but might possibly do \$75. Billets are in light demand and still lighter supply, with prices not determined, possibly \$55 to \$65.

FERRO-ALLOYS

Small prompt lots of ferromanganese have been going at \$175@200 and even higher. For second half the regular price is \$160, delivered. Spiegeleisen is \$57@60, furnace. Electrolytic ferrosilicon is quoted at \$140, delivered, for 75 per cent. Bessemer ferrosilicon is \$59.50 for 10 per cent, \$62.80 for 11 per cent and \$66.10 for 12 per cent, f.o.b. Jackson, Ohio.

The Chemical and Allied Industrial Markets

New York, March 5, 1920.

Buyers are experiencing difficulty in locating supplies in most branches of the chemical market. This condition has been brought about by the heavy exporting of the past few weeks and by certain other details beyond the control of the producers. Many manufacturers are unable to consider any more contracts at present, as their entire production is sold months ahead.

The market continues active in inquiry, with most prices quoted being nominal, as spot material in practically every line is very scarce. *Barium* products have been especially active, and prices have kept pace; producers are sold up and there is very little on the spot market. Quotations ranging from \$140@\$175 per ton have been received on *barium chloride*. *Soda ash* remains scarce. There were some small spot supplies reported sold at \$3 for the light and \$3.10 per cwt. on the dense. *Sodium bisulphate*, powdered, has been active during the past week, with quotations of \$7@\$7.50 per ton for carlots and \$8@\$10 for less than carlots. Supplies on *caustic potash* at present are short, but the price of 25@32c. per lb. holds firm. *Sodium cyanide*, under the influence of weak demand, dropped to 24@25c. for carlots and 26@27c. per lb. for less than carlots, against 30@32c. and 31@34c. of the previous week. *Caustic soda* still remains under pressure of considerable demand with very little improvement in supplies. Present quotations range from \$4.35@\$4.60 per cwt. All *ammonium* products, under the influence of the recent coal shortage, remain firm in price. It is reported that the decreasing supply of English *salammoniac* is now exhausted, and a steady increase in this item is predicted by some. *Ammonium chloride*, granular, white, is being listed at 15@16c. for carlots and 17c. per lb. for less than carlots, while *gray* is slightly lower at 13@13½c. per lb. It is impossible to obtain an exact price on *sodium bichromate*, as prices demanded are based entirely on the quantity asked for. Prices as high as 45c. per lb. have been reported.

COAL-TAR PRODUCTS

There is considerable criticism among the members of this industry concerning the failure of the proposed bill before the Senate to be passed by that body. General opinion seems to have favored the bill if only for the reason of having some protective measures to check the growth of the German dye industry in the United States and at the same time encourage our domestic producers to meet the demands of this country. Under the influence of this unsettled condition the market has remained quiet, with action in price being displayed by only a few of the items which are feeling an acute shortage. *Dimethylaniline* is off the spot market and producers are contracted for several months ahead. A nominal quotation of 95c.@\$1.20 per lb. has been received. The scant supply of the past few weeks on *H acid* has not improved to any extent and the quotation of \$1.60@\$1.75 per lb. still holds firm. *Salicylic acid*, tech., holds firm under the present demand at 43@45c. per lb., while U. S. P., with a slightly heavier demand, is listed at 55c.@60c. per lb.

WAXES

There has been a slight increase over the usual amount of business in the wax market during the past week. Supplies on all grades of *carnauba* are cramped. Nominal quotations have been received, on No. 1, 80@88c. per lb., No. 2 regular, 65@78c., and No. 3, North Country, 46@48c. *Paraffines* remain firm throughout, with a continued heavy foreign demand especially from the Far East.

NAVAL STORES

Turpentine is again on the upward trend due to shortage of supplies in New York, and present market is about \$1.99 per gal. *Rosins* have come up slightly under the pressure of the heavy buying that was felt while prices were down. K-N grades are listed at \$18.50@\$21.50 and B-D at \$17@\$18.50. Foreign inquiry in this market has been at a standstill during the past few weeks and those engaged in this trade are anxiously awaiting a more favorable exchange.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

	Carlots	Less Carlots
Acetic anhydride.....lb.	\$0.16 - \$0.20	\$0.21 - \$0.25
Acetone.....lb.	2.75 - 3.00	3.00 - 3.25
Acid, acetic, 28 per cent.....cwt.	6.00 - 6.50	7.00 - 7.50
Acetic, 56 per cent.....cwt.	12.00 - 12.50	13.50 - 15.50
Acetic, glacial, 99 1/2 per cent, carboys.....cwt.	14 - 15 1/2	15 - 16 1/2
Boric, crystals.....lb.	14 - 15 1/2	15 - 16 1/2
Boric, powder.....lb.	14 - 15 1/2	15 - 16 1/2
Hydrochloric.....lb.	0.8 - 0.9	0.9 - 1.0
Hydrofluoric, 52 per cent.....lb.	12 - 12 1/2	14 - 15
Lactic, 44 per cent tech.....lb.	11 - 11 1/2	12 - 13
Lactic, 22 per cent tech.....lb.	0.5 - 0.6	0.5 - 0.6
Molybdenic, C. P.....lb.	0.6 - 0.7	0.7 - 0.8
Nitric, 40 deg.....lb.	0.6 - 0.7	0.7 - 0.8
Nitric, 42 deg.....lb.	0.6 - 0.7	0.7 - 0.8
Oxalic, crystals.....lb.	0.35 - 0.40	0.4 - 0.45
Phosphoric, Ortho, 50 per cent solution.....lb.	24 - 25	26 - 27
Picric.....lb.	30 - 35	40 - 50
Pyrogallol, resublimed.....lb.	2.50 - 2.55	2.60 - 2.65
Sulphuric, 60 deg., tank cars.....ton	22.00 - 25.00	22.00 - 25.00
Sulphuric, 60 deg., drums.....ton	22.00 - 25.00	22.00 - 25.00
Sulphuric, 66 deg., tank cars.....ton	22.00 - 25.00	22.00 - 25.00
Sulphuric, 66 deg., drums.....ton	22.00 - 25.00	22.00 - 25.00
Sulphuric, 66 deg., carboys.....ton	22.00 - 25.00	22.00 - 25.00
Sulphuric, fuming, 20 per cent (oleum) tank cars.....ton	27.00 - 30.00	32.00 - 35.00
Sulphuric, fuming, 20 per cent (oleum) drums.....ton	32.00 - 35.00	34.00 - 37.00
Sulphuric, fuming, 20 per cent (oleum) carboys.....ton	35.00 - 38.00	40.00 - 43.00
Tannic, U. S. P.....lb.	1.35 - 1.45	1.45 - 1.55
Tannic (tech.).....lb.	0.42 - 0.55	0.55 - 0.65
Tartaric, crystals.....lb.	0.69 - 0.74	0.74 - 0.79
Tungstic, per lb. of WO.....lb.	1.20 - 1.40	1.40 - 1.60
*Alcohol, Ethyl.....gal.	4.80 - 5.50	6.00 - 7.00
*Alcohol, Methyl.....gal.	1.50 - 1.60	1.52 - 1.57
*Alcohol, denatured, 188 proof.....gal.	0.65 - 0.78	0.78 - 0.85
*Alcohol, denatured, 190 proof.....gal.	0.67 - 0.74	0.74 - 0.81
Alum, ammonia lump.....lb.	0.4 - 0.5	0.5 - 0.6
Alum, potash lump.....lb.	0.8 - 0.9	0.9 - 1.0
Alum, chrome lump.....lb.	1.5 - 1.6	1.8 - 2.0
Aluminum sulphate, commercial.....lb.	0.11 - 0.12	0.12 - 0.13
Aluminum sulphate, iron free.....lb.	0.21 - 0.23	0.23 - 0.25
Aqua ammonia, 26 deg., drums (750 lb.).....lb.	0.04 - 0.05	0.05 - 0.06
Ammonia, anhydrous, cylinders (100-150 lb.).....lb.	33 - 35	35 - 37
Ammonium carbonate, powder.....lb.	13 - 16	17 - 19
Ammonium chloride, granular (white sal-ammoniac).....lb.	15 - 16	17 - 19
Ammonium chloride, granular (gray sal-ammoniac).....lb.	13 - 14	14 - 15
Ammonium nitrate.....lb.	10 - 12	12 - 14
Ammonium sulphate.....lb.	0.5 - 0.6	0.6 - 0.7
Amylacetate.....gal.	3.65 - 3.75	3.75 - 3.85
Arsenic, oxide, lumps (white arsenic).....lb.	23 - 24	24 - 25
Arsenic, sulphide, powdered (red arsenic).....ton	140.00 - 150.00	160.00 - 170.00
Barium chloride.....lb.	26 - 27	28 - 30
Barium dioxide (peroxide).....lb.	11 - 12	13 - 14
Barium nitrate.....lb.	0.3 - 0.35	0.35 - 0.4
Barium sulphate (precip.) (blanc fixe).....lb.	0.3 - 0.35	0.35 - 0.4
Bleaching powder (see calcium hypochlorite).....cwt.	2.00 - 2.05	2.10 - 2.15
Blue vitriol (see copper sulphate).....cwt.	2.00 - 2.05	2.10 - 2.15
Borax (see sodium borate).....cwt.	2.00 - 2.05	2.10 - 2.15
Bromine.....lb.	90 - 95	95 - 100
Bromine.....cwt.	2.00 - 2.05	2.10 - 2.15
Calcium acetate.....cwt.	2.00 - 2.05	2.10 - 2.15
Calcium carbide.....lb.	0.1 - 0.15	0.15 - 0.2
Calcium chloride, fused, lump.....ton	20.00 - 25.00	30.00 - 40.00
Calcium chloride, granulated.....lb.	0.1 - 0.15	0.15 - 0.2
Calcium hypochlorite (bleaching powder).....cwt.	2.00 - 2.05	2.10 - 2.15
Calcium peroxide.....lb.	1.50 - 1.70	1.70 - 1.90
Calcium phosphate, monobasic.....lb.	0.6 - 0.8	0.8 - 1.0
Calcium sulphate, pure.....lb.	0.1 - 0.15	0.15 - 0.2
Carbon bisulphide.....lb.	0.6 - 0.8	0.8 - 1.0
Carbon tetrachloride, drums.....lb.	10 - 11	12 - 13
Carbonyl chloride (phosgene).....lb.	80 - 105	105 - 120
Caustic potash (see potassium hydroxide).....cwt.	2.00 - 2.05	2.10 - 2.15
Caustic soda (see sodium hydroxide).....cwt.	2.00 - 2.05	2.10 - 2.15
Chlorine, gas, liquid-cylinders (100 lb.).....lb.	0.5 - 0.55	0.55 - 0.6
Chloroform.....lb.	28 - 29	30 - 31
Cobalt oxide.....lb.	2.00 - 2.05	2.10 - 2.15
Copperas (see iron sulphate).....cwt.	2.00 - 2.05	2.10 - 2.15
Copper carbonate, green precipitate.....lb.	27 - 28	29 - 31
Copper cyanide.....lb.	0.8 - 0.9	0.9 - 1.0
Copper sulphate, crystals.....lb.	0.8 - 0.9	0.9 - 1.0
Cream of tartar (see potassium bitartrate).....cwt.	2.00 - 2.05	2.10 - 2.15
Epsom salt (see magnesium sulphate).....cwt.	2.00 - 2.05	2.10 - 2.15
Formaldehyde, 40 per cent.....lb.	45 - 46	46 - 47
Glauber's salt (see sodium sulphate).....cwt.	2.00 - 2.05	2.10 - 2.15
Glycerine.....lb.	24 - 26	26 - 28
Iodine, resublimed.....lb.	4.10 - 4.30	4.30 - 4.50
Iron oxide, red.....cwt.	1.20 - 1.3	1.3 - 1.4
Iron sulphate (copperas).....cwt.	1.20 - 1.3	1.3 - 1.4
Lead acetate, normal.....lb.	12 - 13	13 - 14
Lead arsenate (paste).....lb.	14 - 15	15 - 16
Lead nitrate, crystals.....lb.	11 - 12	12 - 13
Litharge.....lb.	11 - 12	12 - 13
Lithium carbonate.....lb.	1.50 - 1.70	1.70 - 1.90
Magnesium carbonate, technical.....lb.	3.25 - 3.45	3.50 - 3.75
Magnesium sulphate, U. S. P.....100 lb.	3.00 - 3.10	3.10 - 3.20
Magnesium sulphate, commercial.....100 lb.	14 - 15	15 - 16
Nickel salt, double.....lb.	12 - 13	13 - 14
Nickel salt, single.....lb.	12 - 13	13 - 14
Phosgene (see carbonyl chloride).....lb.	60 - 65	65 - 70
Phosphorus, red.....lb.	32 - 33	33 - 34
Phosphorus, yellow.....lb.	32 - 33	33 - 34
Potassium bichromate.....lb.	56 - 60	60 - 65
Potassium bitartrate (cream of Tartar).....lb.	60 - 65	65 - 70
Potassium bromide, granular.....lb.	26 - 27	27 - 28
Potassium carbonate, U. S. P.....lb.	16 - 20	20 - 25
Potassium chlorate, crystals.....lb.	25 - 32	32 - 35
Potassium hydroxide (caustic potash).....lb.	3.35 - 3.60	3.60 - 3.85
Potassium iodide.....lb.	19 - 20	20 - 21
Potassium nitrate.....lb.	19 - 20	20 - 21
Potassium permanganate.....lb.	\$0.65 - \$0.95	\$0.95 - \$1.25

*Nominal quotations.

	Carlots	Less Carlots
Potassium prussiate, red.....lb.	1.00 - 1.05	1.10 - 1.20
Potassium prussiate, yellow.....lb.	1.00 - 1.05	1.10 - 1.20
Potassium sulphate.....ton	\$225.00	40 - 70
Rochelle salts (see sodium potas. tartrate).....cwt.	18.00 - 21.00	18.00 - 21.00
Salmoniac (see ammonium chloride).....cwt.	1.25 - 1.35	1.35 - 1.45
Salt soda (see sodium carbonate).....cwt.	1.25 - 1.35	1.35 - 1.45
Salt cake (sodium sulphate).....ton	18.00 - 21.00	18.00 - 21.00
Silver cyanide.....lb.	81 - 82 1/2	82 1/2 - 84
Silver nitrate.....oz.	2.50 - 2.60	2.60 - 2.70
Soda ash, light.....100 lb.	2.70 - 2.75	2.75 - 2.80
Soda ash, dense.....100 lb.	0.6 - 0.7	0.7 - 0.8
Sodium acetate.....lb.	2.40 - 2.50	2.50 - 2.60
Sodium bicarbonate.....100 lb.	33 - 34	35 - 36
Sodium bichromate.....lb.	7.00 - 7.50	8.00 - 10.00
Sodium bisulphate (nitre cake).....ton	0.5 - 0.6	0.6 - 0.7
Sodium borate (borax).....lb.	0.8 - 0.9	0.9 - 1.0
Sodium carbonate (sal soda).....100 lb.	1.35 - 1.40	1.50 - 1.75
Sodium chlorate.....lb.	10 - 12	12 - 14
Sodium cyanide, 96-98 per cent.....lb.	24 - 25	26 - 27
Sodium fluoride.....lb.	14 - 15	15 - 16
Sodium hydroxide (caustic soda).....100 lb.	4.85 - 5.25	5.25 - 5.65
Sodium hyposulphite.....lb.	3.25 - 3.50	3.50 - 3.75
Sodium molybdate.....lb.	2.50 - 2.55	2.60 - 2.65
Sodium nitrate.....100 lb.	3.00 - 3.25	3.25 - 3.50
Sodium nitrite.....lb.	15 - 17	17 - 19
Sodium peroxide, powdered.....lb.	30 - 32	32 - 34
Sodium phosphate, dibasic.....lb.	0.3 - 0.4	0.4 - 0.5
Sodium potassium tartrate (Rochelle salts) lb.	40 - 42	43 - 45
Sodium prussiate, yellow.....lb.	23 - 29	30 - 40
Sodium silicate, solution (40 deg.).....lb.	0.1 - 0.2	0.2 - 0.3
Sodium silicate, solution (60 deg.).....lb.	0.2 - 0.3	0.3 - 0.4
Sodium sulphate, crystals (Glauber's salt) cwt.	1.15 - 1.50	1.60 - 2.00
Sodium sulphide, crystal, 60-62 per cent (conc) lb.	0.3 - 0.4	0.4 - 0.5
Sodium sulphite, crystals.....lb.	0.3 - 0.4	0.4 - 0.5
Strontium nitrate, crystals.....lb.	25 - 28	28 - 30
Sulphur chloride.....lb.	0.5 - 0.6	0.6 - 0.7
Sulphur, crude.....ton	22.00	22.00
Sulphur dioxide, liquid, cylinders.....lb.	0.9 - 1.0	1.0 - 1.1
Sulphur (sublimed), flour.....100 lb.	3.35 - 3.40	3.40 - 3.45
Sulphur, roll (brimstone).....100 lb.	3.20 - 3.25	3.30 - 3.40
Tin bichloride (stannous).....lb.	42 - 45	46 - 50
Tin oxide.....lb.	50 - 60	60 - 65
Zinc carbonate, precipitate.....lb.	13 - 14	14 - 15
Zinc chloride, gran.....lb.	49 - 50	50 - 55
Zinc cyanide.....lb.	11 - 12	12 - 13
Zinc dust.....lb.	0.9 - 1.0	1.0 - 1.1
Zinc oxide, dry American.....lb.	0.3 - 0.4	0.4 - 0.5
Zinc sulphate.....lb.	0.3 - 0.4	0.4 - 0.5

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude.....lb.	\$1.00 - \$1.10
Alpha naphthol, refined.....lb.	1.40 - 1.60
Alpha naphthylamine.....lb.	40 - 50
Aniline oil, drums extra.....lb.	34 - 45
Aniline salts.....lb.	42 - 50
Anthracene, 80% in drums (100 lb.).....lb.	2.00 - 2.10
Benzaldehyde (l.f.c.).....lb.	1.25 - 1.35
Benzidine, base.....lb.	1.00 - 1.15
Benzidine, sulphate.....lb.	90 - 100
Benzoic acid, U. S. P.....lb.	80 - 100
Benzonitrile, U. S. P.....lb.	27 - 36
Benzol, pure, water-white, in drums (100 lb.).....gal.	25 - 29
Benzol, 90%, in drums (100 lb.).....gal.	35 - 40
Benzyl chloride, 95-97%, refined.....lb.	25 - 35
Benzyl chloride, tech.....lb.	50 - 55
Beta naphthol benzoyl.....lb.	65 - 80
Beta naphthol, sublimed.....lb.	45 - 55
Beta naphthol, tech.....lb.	2.25 - 2.35
Beta naphthylamine, sublimed.....lb.	16 - 18
Cresol, U. S. P., in drums (100 lb.).....lb.	23 - 25
Ortho-cresol, in drums (100 lb.).....lb.	85 - 100
Cresylic acid, 92-99%, straw color, in drums.....gal.	60 - 70
Cresylic acid, 95-97%, dark, in drums.....gal.	60 - 70
Cresylic acid, 50%, first quality, drums.....lb.	0.7 - 1.0
Dichlorobenzol.....lb.	1.40 - 1.50
Diethylaniline.....lb.	95 - 120
Dimethylaniline.....lb.	26 - 37
Dinitrobenzol.....lb.	25 - 30
Dinitrochlorobenzol.....lb.	45 - 55
Dinitronaphthalene.....lb.	32 - 36
Dinitrophenol.....lb.	38 - 45
Dinitrotoluol.....lb.	38 - 40
Dip oil, 25%, tar acids, car lots, in drums.....gal.	55 - 65
Diphenylamine.....lb.	1.60 - 1.75
H-acid.....lb.	1.15 - 1.80
Metaphenylenediamine.....lb.	12 - 15
Monochlorobenzol.....lb.	1.50 - 1.75
Monothylaniline.....lb.	0.6 - 0.8
Naphthalene crushed, in bbls. (250 lb.).....lb.	0.7 - 0.8
Naphthalene, flake.....lb.	0.8 - 1.0
Naphthalene, balls.....lb.	1.25 - 1.35
Naphthionine acid, crude.....lb.	14 - 19
Nitrobenzol.....lb.	30 - 35
Nitro-naphthalene.....lb.	20 - 30
Nitro-toluol.....lb.	3.75 - 4.25
Ortho-amidophenol.....lb.	15 - 20
Ortho-dichlorobenzol.....lb.	80 - 125
Ortho-nitro-phenol.....lb.	25 - 40
Ortho-nitro-toluol.....lb.	25 - 45
Ortho-toluidine.....lb.	2.50 - 3.50
Para-amidophenol, base.....lb.	2.50 - 3.25
Para-amidophenol, HCl.....lb.	12 - 18
Para-dichlorobenzol.....lb.	1.00 - 1.35
Paranitraniline.....lb.	1.35 - 1.50
Para-nitro-toluol.....lb.	2.15 - 3.00
Paraphenylenediamine.....lb.	1.75 - 2.50
Paratoluidine.....lb.	60 - 70
Phthalic anhydride.....lb.	12 - 25
Phenol, U. S. P., drums (dest.), (240 lb.).....gal.	2.00 - 2.50
Pyridin.....lb.	3.75 - 4.50
Resorcin, technical.....lb.	6.50 - 6.75
Resorcin, pure.....lb.	43 - 45
Salicylic acid, tech., in bbls. (110 lb.).....lb.	55 - 60
Salicylic acid, U. S. P.....lb.	55 - 60

Solvent naphtha, water-white, in drums, 100 gal.	gal.	\$0.22	—	\$0.27
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19	—	.24
Sulphanilic acid, crude	lb.	.25	—	.30
Toluidine	lb.	1.70	—	2.50
Toluidine, mixed	lb.	.45	—	.55
Toluol, in tank cars	gal.	.28	—	.32
Toluol, in drums	gal.	.29	—	.32
Xylidine, drums, 100 gal.	gal.	.44	—	.50
Xylol, pure, in drums	gal.	.37	—	.45
Xylol, pure, in tank cars	gal.	.35	—	.45
Xylol, commercial, in drums, 100 gal.	gal.	.37	—	.45
Xylol, commercial, in tank cars	gal.	.23	—	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	\$0.42	—	\$0.45
Beeswax, refined, yellow	lb.	.47	—	.48
Beeswax, white pure	lb.	.63	—	.68
Carnauba, No. 1, (nominal)	lb.	.80	—	.88
Carnauba, No. 2, regular (nominal)	lb.	.65	—	.78
Carnauba, No. 3, North Country (nominal)	lb.	.46	—	.48
Japan	lb.	.17	—	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	—	—	.07½
Paraffine waxes, crude, scale 124-126 m.p.	lb.	—	—	.10½
Paraffine waxes, refined, 118-120 m.p.	lb.	—	—	.08
Paraffine waxes, refined, 128-130 m.p.	lb.	.11	—	.11½
Paraffine waxes, refined, 133-135 m.p.	lb.	—	—	.13
Paraffine waxes, refined, 135-137 m.p.	lb.	—	—	.14
Stearic acid, single pressed	lb.	.23	—	.26
Stearic acid, double pressed	lb.	.28	—	.29
Stearic acid, triple pressed	lb.	.32	—	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr. 0.930-0.940	gal.	\$1.45	—	—
Pine oil, pure, dest. dist.	gal.	—	—	.40
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	—	—	.48
Pinetaroil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	—	—	.70
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	—	—	.38
Pine tar, ref., thin, sp. gr. 1.080-1.060	gal.	—	—	1.60
Turpentine, crude, sp. gr. 0.900-0.970	gal.	—	—	.35
Hardwood oil, f.o.b. Mich., sp. gr. 0.960-0.990	gal.	—	—	.52
Pinewood creosote, ref.	gal.	—	—	—

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	\$17.00	—	\$18.50
Rosin E-I	280 lb.	18.05	—	18.75
Rosin K-N	280 lb.	18.50	—	21.50
Rosin W. G. W. W.	280 lb.	21.50	—	24.25
Wood rosin, bbl.	280 lb.	15.50	—	17.50
Spirits of turpentine	gal.	—	—	1.99
Wood turpentine, steam dist.	gal.	—	—	1.93
Wood turpentine, dest. dist.	gal.	—	—	1.85
Pine tar pitch, bbl.	200 lb.	8.50	—	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	—	14.75
Retort tar, bbl.	500 lb.	15.00	—	15.25
Rosin oil, first run	gal.	.93	—	.95
Rosin oil, second run	gal.	.96	—	.97
Rosin oil, third run	gal.	1.10	—	1.15
Rosin oil, fourth run	gal.	—	—	1.18

Solvents

73-76 deg., steel bbl. (85 lb.)	gal.	\$0.334	—	—
70-72 deg., steel bbl. (85 lb.)	gal.	.314	—	—
68-70 deg., steel bbl. (85 lb.)	gal.	.304	—	—
V. M. and P. naphtha, steel bbl. (85 lb.)	gal.	.234	—	—

Crude Rubber

Para-Upriver fine	lb.	\$0.42½	—	\$0.44
Upriver coarse	lb.	.31	—	.35
Upriver cauche ball	lb.	.31	—	.34½
Plantation—First latex crepe	lb.	.47	—	.49
Ribbed smoked sheets	lb.	.46	—	.48
Brown crepe, thin, clean	lb.	.41	—	.43
Amber crepe No. 1	lb.	.45	—	—

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	\$0.19	—	\$0.20
Castor oil, AA, in bbls.	lb.	.20	—	.23
China wood oil, in bbls.	lb.	.23½	—	.25½
Cocconut oil, Ceylon grade, in bbls.	lb.	.18½	—	.19½
Cocconut oil, Cochon grade, in bbls.	lb.	.20½	—	.23
Corn oil, crude, in bbls.	lb.	.19	—	.22
Cottonseed oil, crude (f.o.b. mill)	lb.	17.50	—	18.00
Cottonseed oil, summer yellow	lb.	19.00	—	20.00
Cottonseed oil, winter yellow	lb.	.24½	—	.25½
Linseed oil, raw, car lots	gal.	1.77	—	—
Linseed oil, raw, tank cars	gal.	1.72	—	—
Linseed oil, boiled, car lots	gal.	1.80	—	—
Olive oil, commercial	gal.	2.50	—	3.00
Palm, Lagos	lb.	.16	—	.16½
Palm, bright red	lb.	.15½	—	.17½
Palm, Niger	lb.	.15	—	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.22½	—	.24
Peanut oil, refined, in bbls.	lb.	.27	—	.28
Rapeseed oil, refined in bbls.	gal.	1.70	—	—
Rapeseed oil, blown, in bbls.	gal.	1.60	—	1.70
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.18½	—	.23
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.16½	—	.20

FISH

Winter pressed Menhaden	gal.	\$1.15	—	—
Yellow bleached Menhaden	gal.	1.20	—	—
White bleached Menhaden	gal.	1.22	—	—
Blown Menhaden	gal.	1.28	—	—

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	\$35.00	—	\$40.00
Barytes, off color	ton	20.00	—	25.00
Blanc fixe, dry	lb.	.04½	—	.05½
Blanc fixe, pulp	ton	30.00	—	50.00
Casein	lb.	.16	—	.18
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.04½	—	.06
Chalk, English, dense	lb.	.04	—	.05
China clay (Kaolin), imported, lump	ton	25.00	—	35.00
China clay (Kaolin), imported, powdered	ton	30.00	—	60.00
China clay (Kaolin), domestic, lump	ton	10.00	—	20.00
China clay (Kaolin), domestic, powdered	ton	25.00	—	40.00
Feldspar	ton	13.50	—	18.00
Fluor spar, acid grade, lump, f.o.b. mines	net ton	30.00	—	45.00
Fluor spar, acid grade, ground, f.o.b. mines	net ton	50.00	—	52.00
Fuller's earth, domestic, powdered	ton	25.00	—	30.00
Fuller's earth, imported, powdered	ton	35.00	—	40.00
Graphite, crucible, 85% carbon content	lb.	—	—	.07½
Graphite, crucible, 86% carbon content	lb.	—	—	.08
Graphite, crucible, 87% carbon content	lb.	—	—	.07
Graphite, crucible, 88% carbon content	lb.	—	—	.08½
Graphite, crucible, 89% carbon content	lb.	—	—	.08½
Graphite, crucible, 90% carbon content	lb.	—	—	.09
Graphite, crucible, 91% carbon content	lb.	—	—	.08½
Graphite, crucible, 92% carbon content	lb.	—	—	.09½
Graphite, crucible, plus 92%	lb.	—	—	.12
Pumice stone, imported	lb.	.03	—	.06
Pumice stone, domestic	lb.	.02½	—	—
Shellac, orange, fine	nominal lb.	1.55	—	1.60
Shellac, orange, superfine	lb.	1.65	—	1.70
Shellac, A. C. garnet	lb.	1.30	—	1.35
Soapstone	ton	15.00	—	25.00
Talc, domestic	ton	16.00	—	60.00
Talc, imported	ton	60.00	—	70.00

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	38-45 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	33-35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-85 at Chester, Penn.
Silica brick	1,000	45-50 at Mt. Union, Penn.

Ferro-Alloys

All Prices f.o.b. works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	\$200.00	—	\$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20	—	.21
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.21	—	.22
Ferro-manganese, 70-80% Mn.	gross ton	160.00	—	170.00
Spiegelisen, 16-20% Mn.	gross ton	50.00	—	60.00
Ferro-molybdenum, per lb. of Mo.	lb.	2.50	—	2.75
Ferro-silicon, 50%	gross ton	85.00	—	95.00
Ferro-silicon, 75%	gross ton	150.00	—	175.00
Ferro-silicon, 10-15%	gross ton	45.00	—	60.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	.90	—	1.10
Ferro-uranium, 35-50%, of U.	lb.	7.00	—	—
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	6.50	—	7.50

Ores and Semi-finished Products

Chrome ore, 35-40% Cr ₂ O ₃	unit	\$0.60	—	\$0.65
Chrome ore, 48% and over	unit	1.00	—	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00	—	—
*Coke, furnace, f.o.b. ovens	net ton	6.00	—	—
Petroleum coke, refinery, Atlantic seaboard	net ton	—	—	14.00
Fluor spar, gravel, f.o.b. mines	net ton	—	—	25.00
Manganese ore, 45% Mn and over	unit	.75	—	.85
Manganese ore, chemical (MnO ₂)	gross ton	80.00	—	90.00
Molybdenite, 85% MoS ₂ , per lb. of MoS ₂	lb.	.75	—	.85
Tungsten, Scheelite, 60% WO ₃ and over, per unit of WO ₃	unit	9.00	—	15.00
Tungsten, Wolframite, 60% WO ₃ and over, per unit of WO ₃	unit	7.50	—	10.00
Uranium oxide, 96%	lb.	2.75	—	3.00
Vanadium pentoxide, 99%	lb.	6.00	—	—
Pyrites, foreign, lump	unit	.17	—	—
Pyrites, foreign, fine	unit	.17	—	—
Pyrites, domestic, fine	unit	.16	—	.17½
Ilmenite, 52% TiO ₂	lb.	.02	—	—
Rutile, 95% TiO ₂	lb.	.11	—	—
Carnotite, minimum 2% U ₂ O ₅ , per lb. of U ₂ O ₅	lb.	2.75	—	3.00
Zircon, washed, iron free	lb.	.10	—	—
Monazite, per unit of ThO ₂	unit	42.00	—	—

*Government prices.

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 15-in.	100 lb.	\$2.45
Angles, 3 to 6-in., ½-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.65
Rivets, structural, ½-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ½-in. and larger	100 lb.	4.50
Sheets, No. 28 black	100 lb.	4.85
Sheets, No. 10 blue annealed	100 lb.	4.00
Sheets, No. 28 galvanized	100 lb.	6.20

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Connecticut

MIDDLETOWN—Wesleyan University, 374 High St., is having plans prepared for the construction of a 2-story chemical laboratory. Estimated cost, \$500,000. Henry Bacon, 101 Park Ave., New York City, archt. and engr.

Idaho

OROFINO—The Crustaline Lime Co. is in the market for a 125-ton daily capacity rotary kiln, etc. Total estimated cost, \$100,000.

Illinois

CHICAGO—The Steel Sales Corp., 129 South Jefferson St., has purchased a site at Crawford Ave. and 35th St. and plans to build a 1-story, 400 x 600-ft. steel fabrication plant on same. Estimated cost, \$250,000.

HIGHLAND PARK—The city is having plans prepared and estimates submitted for the construction of a filtration plant, extensions to distribution system and installation of a 5,000,000-gal. additional pumping equipment. Alvord Burdick, 8 South Dearborn St., Chicago, engr.

KEWANEE—The city is having a study made of its problem of sewage disposal. Alvord & Burdick, 8 South Dearborn St., Chicago, engr.

ROCKFORD—The city is having plans prepared for the construction of an intercepting sewer and a disposal plant. Alvord & Burdick, 8 South Dearborn St., Chicago, engr.

Indiana

BLOOMINGTON—The city is having plans prepared for the enlargement of present sewage disposal plant. Alvord & Burdick, 8 South Dearborn St., Chicago, engr.

KOKOMO—The Pittsburgh Plate Glass Co., Vaile Ave., has awarded the contract for the construction of new buildings and extensions to its plant, here, to Stone & Webster, 120 B'way, New York City. Estimated cost, \$2,000,000. J. W. Buzzell, contract mgr.

SEYMOUR—The Water Co. plans to improve power station. Improvements consist of a new sedimentation basin of 2,000,000-gal. capacity and rebuilding of the steam plant.

Iowa

AMES—The city had plans prepared for the construction of a sewage disposal plant, consisting of pumping plant, Imhof tank, sludge bed and trickling filters, etc. Estimated cost, \$100,000. P. E. Hopkins, mgr. dept. of engr.

OAKDALE—The Bd. of Control, State House, Des Moines, will soon award the contract for the construction of a 2-story laboratory in connection with the State Sanatorium, here. H. F. Liebbe, State House, Des Moines, archt.

Kansas

COFFEYVILLE—The Kansas Oil Refining Co. plans to build additions to its oil refinery, 2 mi. from here. Estimated cost, \$500,000. H. R. Heal, genl. mgr.

Louisiana

NEW ORLEANS—The New Orleans Gas Light Co., Bayonne and Common Sts., has awarded the contract for the installation of a new purification system in its proposed plant, to the Western Gas Constr. Co., Fort Wayne, Ind. Estimated cost, \$312,000.

NEW ORLEANS—The Surgical Supply Co., 1425-1427 Canal St., is in the market for buffing machines, nickel plating equipment, etc. John A. Moran, secy. and treas.

Maryland

BALTIMORE—The Baltimore Copper Smelting & Rolling Co., 4th

Ave. and 5th St., had plans prepared for the construction of a 1-story, 204.3 x 329.8-ft. copper rolling mill at 1st and 2nd Sts. and 3rd Ave. Estimated cost, \$130,000.

Massachusetts

CAMBRIDGE—Lever Bros. Co., Portland St., is having plans prepared for the construction of a 6-story mfg. plant addition. C. Timain, 201 Devonshire St., Boston, archt. and engr.

CHESTNUT HILL (Boston P. O.)—Boston College, University Heights, is having plans prepared for the construction of a 5-story chemical and physical laboratory on the campus, here. Maginnis & Walsh, 100 Boylston St., Boston, archts. and engr.

LEE—The Smith Paper Co. has awarded the contract for the construction of a 2-story, 50 x 140-ft. paper mill, here, to the Lynch Bros. Brick Co., Holyoke. Estimated cost, \$60,000.

WEST SPRINGFIELD (Springfield P. O.)—The Gilbert & Barker Mfg. Co., Cold Springs Ave., will soon award the contract for the construction of 5 factory buildings, including a 1-story, 80 x 400-ft. brass foundry, 1-story, 40 x 80-ft. zinc building, a 1-story, 160 x 230-ft. sheet metal building, etc. Estimated cost, \$750,000. McClintock & Craig, 33 Lyman St., Springfield, archts. and engr.

Michigan

DETROIT—The General Testing Laboratories, analytical and research chemists, 97 Woodward Ave., plan to enlarge their plant and are in the market for equipment for general physicians' analytical work and bacteriology. J. A. Wolf, genl. mgr.

MARYSVILLE—Smith, Hinchman & Grylls, archts. and engr., 710 Washington Arcade, Detroit, will soon award the contract for the construction of a 1- and 2-story, 380 x 420-ft. foundry at Michigan Ave. and Cattle Rd., for the General Aluminum & Brass Co., Boulevard and St. Aubin Sts., Detroit. Estimated cost, \$500,000.

MILFORD—The village is making surveys and plans and submitting estimates for the construction of a complete sewer system, including vitrified sewers and disposal works. Estimated cost, \$100,000. C. W. Hubbell, 2348 Penobscot Bldg., Detroit, engr.

PLEASANT RIDGE (Detroit P. O.)—The village plans to construct complete storm water and sanitary sewer systems with sewage disposal works in the streets in the vicinity of Woodward Ave. C. W. Hubbell, 2348 Penobscot Bldg., engr.

Minnesota

DULUTH—The Northwest Products Co., c/o Marshall Wells Co., Lake Ave., has awarded the contract for the construction of a 1-story, 44 x 60-ft. paint mfg. plant, to Jacobson Bros., 410 Columbia Bldg. Estimated cost, \$15,000.

Nebraska

LINCOLN—The city, together with four suburbs, is having a report prepared for the construction of additional intercepting sewers and sewage disposal plant. Alvord & Burdick, 8 South Dearborn St., Chicago, engr.

New Jersey

BAYONNE—The Nitrate Agencies Co. will build a factory on West 1st St. Estimated cost, \$50,000.

New York

BUFFALO—The General Drop Forge Co., 1738 Elmwood Ave., is having plans prepared for the construction of a 1-story, 100 x 100-ft. heat-treating plant. Estimated cost, \$75,000. Ernest McGeorge, 1900 Euclid Ave., Cleveland, O., archt. and engr.

NEW YORK—The Bd. of Purchase, Municipal Bldg., will receive bids until March 12 for furnishing and delivering copper sulphate to the dept. of Water Supply, Gas and Electricity. Grover A. Whalen, chairman.

NEW YORK—The Natl. Gum & Mica Co., 12 West End Ave., will build a 25 x 100-ft. factory on West End Ave. Work will be done by day labor. Noted Feb. 4.

SALAMANCA—The Kendall Refining Co., Kendall Ave., Bradford, Pa., plans to construct a 2-story, 30 x 40-ft. office and storage building and three steel, 12,000-gal. tanks, on Broad St. Estimated cost, \$50,000-\$60,000.

Ohio

ASHLAND—R. A. Davis, Mayor and Pub. Serv. Dir., City Hall, will receive bids until March 16 for the construction of a filter building and installation of equipment in same. Noted Feb. 18.

CLEVELAND—The Aetna Rubber Co., 815 East 79th St., plans to construct a 1- and 2-story, 100 x 130-ft. factory. Estimated cost, \$100,000. H. Kappler, mgr.

Pennsylvania

HOLMSBURG JUNCTION (Philadelphia P. O.)—The Precision Grinding Wheel Co., manufacturer of grinding wheels, 1215 Filbert St., Philadelphia, is building the first unit of a modern plant on the New York Division of the Pennsylvania R.R. Complete equipment will be installed in same. Grinding wheels made of synthetic corundum or crystallized aluminum oxide, also silicon carbide, will be manufactured by the vitrified, shellac, silicate and rubber processes. H. A. Plusch, mgr.

SPRINGDALE—The West Pennsylvania Power Co. is receiving bids for furnishing filter equipment for the proposed 1,000,000-gal. filtration plant. Chester & Fleming, Union Bk. Bldg., Pittsburgh, engr.

STEELTON—C. P. Turner, engr., Bethlehem Steel Co., is building a 2-story, 50 x 100-ft. laboratory, for the Bethlehem Steel Co. Estimated cost, \$50,000. Bissel & Sinkler, Otis Bldg., Philadelphia, archts.

Texas

ORANGE—The Mogul Oil Refining Co. plans to build a 10,000-bbl. refinery. Estimated cost, \$1,000,000.

Wisconsin

CARROLLVILLE—H. J. Esser, archt., Camp Bldg., Milwaukee, will soon award the contract for the construction of a 3-story, 375 x 500-ft. food factory, here, for the United States Glue Co. Estimated cost, \$500,000.

MILWAUKEE—The Sewage Comm. will receive bids until April 8 for furnishing and installing a fine screen plant for the sewage disposal plant. T. Chalkley Hatton, chief engr.

RACINE—The Racine Mfg. Co., 6th and Mead Sts., is receiving bids for the construction of a 1-story, 100 x 150-ft. dry kiln on Mead St.

Quebec

MONTREAL—The Dominion Glass Co., Wellington St., is in the market for a platinum evaporating dish of a 125 c.c. capacity to be used for laboratory work. C. K. McLeod, chemist.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its fifth annual convention at the Planters Hotel in St. Louis, May 10 and 11.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive, in St. Louis. Headquarters will be at the Hotel Statler.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9 and 10. Headquarters will be at the Copley-Plaza Hotel.

THE AMERICAN ELECTROCHEMICAL SOCIETY, NEW YORK SECTION, will hold a meeting on March 26, the subject of which is "Peace Uses for War Products."

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its semi-annual meeting in Montreal, June 21 and 22; Ottawa, June 23; Shawinigan, June 24 and 25, and La Tuque, June 26.

THE AMERICAN PETROLEUM LEAGUE will hold a meeting in Chicago, March 26 to 29.

THE CHEMICAL SOCIETY OF THE COLLEGE OF THE CITY OF NEW YORK is pleased to announce the following lectures for the spring semester of 1920 to be delivered in the Doremus Lecture Theatre: "Helium," Monday, March 29, at 4 P.M., Dr. R. B. Moore, chief

chemist, U. S. Bureau of Mines (*Lantern*): "Romance of Leather Making," Tuesday, April 13, at 4 P.M., E. A. Brand (*Lantern*): "Water Supply and Drainage in War Cantonnements," Wednesday, April 21, at 4 P.M., Prof. D. D. Jackson, administrative head, department of chemical engineering, Columbia University (*Lantern*): "Modern Coke and Gas Manufacture" (Koppers Process), Thursday, April 29, at 4 P.M., E. L. Crowe (*Lantern and cinema*): "Chemical Naval Warfare," Friday, May 7, at 4 P.M., Prof. James Kendall, professor of chemistry at Columbia University; "Fighting Fire—Fire-foam," Friday, May 14, at 4 P.M., F. A. Epps, chief engineer, the Foamite Fire-foam Co. (*Experimental, cinema and lantern*).

THE FARADAY SOCIETY (London) will hold a meeting on March 23, at which there will be a general discussion on "Basic Slag From the Metallurgical and Agricultural Standpoints."

THE INSTITUTE OF METALS will hold its annual general meeting March 11 and 12 at the Institute of Mechanical Engineers, Storey's Gate, Westminster, S. W. 1, London, England.

INSTITUTE OF METALS DIVISION OF THE A.I.M.E. will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

THE IRON AND STEEL INSTITUTE (London) will hold its annual meeting May 6 and 7, 1920, at the House of the Institute of Civil Engineers, Great George St., London, S. W. 1. The retiring president, Eugene Schneider, will induct into the chair Dr. J. E. Stead, the president-elect.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15. Chinese delegates have chartered the S. S. Ecuador for transportation to this conference.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its spring meeting at the Hotel Waldorf and the Hotel Astor, New York City, April 12 to 16.

Industrial Notes

THE GLIDDEN CO. of Cleveland has taken over the Yarnan Rosin & Turpentine Co. of Brunswick, Ga., and Gulfport, La.

THE AMERICAN METALLURGICAL CORP., Franklin Trust Bldg., Philadelphia, Pa., announces the opening of an office at Credland Chambers, 111 Queen St., Sheffield, England, the title of the headquarters there to be the Midland Metallurgical Ltd. The foreign headquarters will be under the direction of Becroft & Partners, an old and well known engineering organization of Staffordshire, England, G. C. Castle to be directly in charge. The foreign headquarters will carry on the same type of work as carried on by the American Metallurgical Corp., namely, covering the entire field of electrometallurgy and chemical developments.

R. C. GOSROW, metallurgical engineer and electrometallurgist, announces the establishment of his office at 701 Claus Spreckels Bldg., San Francisco, Cal., to engage in consulting work on the metallurgy of iron, steel, ferro-alloys and ore-reduction processes, the heat treatment of steel and steel improvement, the design, construction and operation of electric furnaces, electric furnace processes. He will also be Western representative for the Pittsburgh Furnace Co. of Milwaukee, Wis.

C. R. HAYWARD, assistant professor of metallurgy at the Massachusetts Institute of Technology, and H. M. Schleicher, formerly director of the Central Research Laboratory of the U. S. Smelting, Refining & Mining Co., have opened an office under the name of Hayward & Schleicher at 69 Massachusetts Ave., Cambridge, Mass., as research metallurgists.

THE WILKENS-ANDERSON CO., Chicago, Ill., announces that W. G. Calkins of Detroit, Mich., has developed a new combustion boat for the determination of carbon in steel, known as the NoNoX combustion boat, which is a practically non-oxidizing metallic boat, combining the refractory qualities of non-metallic boats such as porcelain, silica, etc., with the strength and shock resisting properties of a metal. This company also announces that Herbert S. Wilson, chief chemist of the Collins Safety Razor Co., has devised the Wilson carbon determination apparatus, which is a new departure.

THE MONO CORP. OF AMERICA, 48 Coal & Iron Exch., Buffalo, N. Y., announces that it has purchased the entire stock of Mono apparatus and accessories from the F. D. Harger Co., Buffalo, N. Y. This includes all rights for the manufacture and sale of its various types of Mono apparatus for the automatic analysis of CO₂, CO, O, H, SO₂, N, Cl, etc. F. D. Harger has not severed his connection, but will serve as general manager of the new corporation. A service and inspection department, connected with the laboratory, is now in operation and a competent chemical engineer in charge. Capable erectors will be placed at the disposal of customers in connection with the erection of new work and regular inspection trips will be arranged to visit existing installations with a view to bringing about closer co-operation between the customer and the corporation.

GEORGE B. CAREY AND ASSOCIATES of Lexington, Ky., have purchased the Chinn Mineral Co.'s calcite and baryta fields at Muncy's Landing, near Harrodsburg, Ky., and plan to start working them at once.

THE SHERWIN-WILLIAMS CO. has recently purchased the Acme White Lead & Color Works of Detroit and Frank Hemingway & Co., manufacturers of chemicals, dyes and insecticides, with plants at New York and Bound Brook, N. J. This old established Cleveland concern owns lead and zinc mines, operates its own smelter, lead corroding plants, lithopone plant, linseed oil mill, dye and color plants and can factory. It owns the Sherwin-Williams Co. of Canada, Louis Berger & Sons, Ltd., of London and Louis Berger & Son and the Sherwin-Williams Co. of Australia.

THE ESSEX ANILINE WORKS, INC., will remove its present main offices at 39 Oliver St. to 88 Broad St., Boston, Mass. The laboratory will remove to the works at South Middleton, Mass., and shipments of dyestuffs will be made from that point.

THE MICHIGAN SMELTING & REFINING CO., Detroit, Mich., announces that at the annual meeting, held in the administration offices, John R. Searles was elected president and general manager to succeed the late Joseph Sillman, founder of the business. Other officers and directors were elected as follows: Norman Sillman, vice-president; Henry Levitt, secretary and treasurer; directors: John R. Searles, Emory W. Clark, Walter P. Cryslar, Leo M. Butzel, Henry Levitt, Norman Sillman and Chas. O. Patch.

THE PRECISION GRINDING WHEEL CO., Philadelphia, Pa., has recently secured the services of H. A. Plush as secretary and factory manager, and A. S. Vane has been made president and manager.

THE MATHIESON ALKALI WORKS, INC., has established its headquarters in New York City, and hereafter it will sell all of its products direct, instead of, as heretofore, disposing of the greater part through Arnold Hoffman Co., Inc., of Providence, R. I. The company expects to occupy its permanent executive and general offices at 25 West 43rd St., New York, on and after March 5. Accordingly on and after that date, all communications should be sent to that address.

J. C. HENRIQUES and M. A. STONE, JR., have organized a staff of consulting engineer, and formed the Engineering & Appraisal Co., Inc., with offices at 103 Park Ave., New York, opposite Grand Central Station. Their field of work will cover the design and construction of mills, factories, power plants and chemical works; the design and development of special machinery and the formulation of commercial propositions on which the formation of new manufacturing corporations may be based. The company is prepared to design and construct industrial plants for every purpose. Members of the staff are specialists in the utilization of waste steam and the application of steam to chemical and other processes; the derivation of oxygen, nitrogen and other gases; the application of refrigeration and cold storage; the evaporation and concentration of solutions and liquids, and the design and development of special machinery.

THE ADVERTISING ENGINEERS, INC., 50 Union Sq., New York City, has opened an office for the purpose of carrying on the business of counselors and complete service for advertisers of engineering and technical products. Curtis F. Columbia will act as Eastern manager. He was formerly publicity engineer for the New Jersey Zinc Co. and the United States Gypsum Co. and has for a great number of years been closely connected with the metallic industries. Associated with Mr. Columbia are Virgil G. Marani, former Building Commissioner of Cleveland; Victor Hugo Halperin, formerly advertising manager of the General Fireproofing Co.; F. W. Leggett, director of publicity of the Bell Telephone Co.

Manufacturers' Catalogs

THE AMERICAN STAVE & COOPERAGE CO., Chelsea, Mass., is distributing a booklet on its tanks, profusely illustrated.

THE METALLURGICAL RESEARCH ENGINEERING CO., Chicago, Ill., is issuing a series of useful charts giving in tabular form results of a number of physical tests on the steels of various analyses and heat treatments.

THE LINK-BELT CO., Chicago, Ill., has just issued two new catalogs. Book No. 375, entitled "Link-Belt Labor-Saving Elevators and Conveyors," illustrates and describes in 108 pages the many different types and the purposes to which they can be used. Book No. 380 is on electric hoists and overhead cranes, which covers in 100 pages electric hoists, monorail trackwork for electric hoists, electric telfers, overhead traveling cranes and revolving locomotive cranes, which are illustrated and described.

THE CUTLER-HAMMER MFG. CO., Milwaukee, Wis., is issuing a new small folder describing C-H Electric Space Heaters known as Pub. 494. One of the illustrations shows the space heater with a 2-ft. rule held alongside to illustrate further the fact that this heater is 2 ft. long. It is referred to in the folder as "Two Feet of Electrical Heat." A large broadside has also been printed, reproducing many of the current advertisements on this space heater and including in it a list of publications in which the advertisements are appearing, together with the dates. This company has also issued two booklets: Booklet A, on "Motor-Operated Brakes for Alternating Current Service," and Booklet S, on "C-H Magnetic Separators."

THE WALTER A. ZELNICKER SUPPLY CO., St. Louis, Mo., is distributing a folder (No. 275) giving a list of the special offerings of rails, cars, locomotives, steam shovels, generator sets, air compressors, engines, boilers, hoisting engines, pipe, steel piling, tanks, etc.

THE NORTON CO., Worcester, Mass., has just issued nine booklets as follows: Health Bulletin; Storage, Handling and Supervision of Grinding Wheels; Safety as Applied to Grinding Wheels; Alundum Tile and Terrazzo Aggregates; Test of Alundum Tile at Columbia University; Safety Code for the Use, Care and Protection of Abrasive Wheels; Indiana Hill an Industrial Village, by Clifford S. Anderson; Principles of Cylindrical Grinding and Norton Service.

HOLZ & CO., INC., New York City, is distributing Bull. No. 22-23, on the Holz Universal Photo-Micrographic and Macrographic Metallographic Bench Model 1920, for magnifications from 1 to 3,500 diameters, with apparatus for "selective" vertical illumination and other important improvements.

W. S. ROCKWELL CO., New York, has issued Bull. 200, which illustrates and describes in detail a new and novel type of furnace—side-opening heat-treatment furnace. It was developed to heat treat material varying widely in shape and size. This furnace is 36 ft. wide. Stock approximately this length may be placed in the furnace for heat treatment, or the furnace may be partitioned off into individual chambers 5 ft. 9 in. wide or multiples thereof. Thus, while one chamber was heating stock say 5 ft. long, the other part of the furnace could be heating stock either much longer than 5 ft. or smaller. This furnace is now being widened to provide a working chamber 105 ft. wide in the clear, the length remaining the same. This increased width will provide facilities to anneal and heat treat the largest shafts and similar pieces handled in this forge shop. The doors of the furnace can be raised or lowered independently of one another. They are operated by compressed air and counterweights. They are dovetailed and form guides within themselves that prevent the escape of hot gases. The roof of the furnace is constructed of flat tiles, avoiding the thrust caused by the ordinary arch construction. The furnace is underfired, assuring a uniform heat treatment. It is provided with preheaters over the vents. The air in these preheaters thus returns through the burners the greater portion of the heat in the spent gases that would otherwise be lost. The fuel consumption in this furnace is extremely low, due to the efficient application of the heat and the utilization of the waste heat ordinarily lost. Oil or gas may be used as fuel. Expansion of the brickwork, or of the furnace as a whole, is taken up by the heavy springs at the side of the furnace.